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

Medical Entomology

2016/2017
Annual Report

Environmental Health Hazards Unit
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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;
- Population Health Units/Area Health Services
- 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 2016/17 (1 July 2016 to 30 June 2017) and an update for northern fieldwork data from 2015/16.

Mosquito-borne disease case data:

Ross River virus (RRV): The total number of notified human cases of RRV infections for WA in 2016/17 was 1115. The number of reported cases was significantly lower than monthly five year moving average from July 2016 to February 2017 and was above or close to the moving average from March 2017 onwards.

Barmah Forest virus (BFV): A total of 33 human cases of BFV were notified in WA for 2016/17. The number of cases reported during February and March 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: There was one human case of MVE notified to the Department of Health during 2016/17. This remains an unconfirmed case pending follow-up serology results.

West Nile virus Kunjin strain (WNV_{KUN}): Four confirmed human cases of WNV_{KUN} disease were notified to the Department of Health during 2016/17. All cases were in Broome residents; the confirmed cases indicated that they were exposed in and around the Broome area.

Climatic Conditions:

Rainfall was above average for the majority of the state, particularly the north and interior regions of WA in February and March 2017. However, south-western parts of WA received average or below average rainfall for most of the year. Minimum temperatures were significantly above average in the north and interior regions, and below average in the south. Maximum temperatures were close to average for most of the state and below average particularly during summer and winter months. Tropical Cyclone Yvette was the only cyclone to cross the WA coastline during 2016/17 though there was little impact to the mainland. Two consecutive Tropical Low systems delivered heavy rainfall between January and March resulting in flooding in some regions and increases in mosquito populations.

Mosquito-Borne Disease Surveillance

Southwest RRV/BFV Surveillance Program: A total of 61,948 mosquitoes were collected, and RRV was detected at 10 of 21 routine surveillance sites. Detections ranged from the most northerly site at Lake Goegrup on 8th September 2016 to the most southerly site at Quindalup on 28th November 2016. BFV was detected at Lake Goegrup from a pool of *Ae. camptorhynchus* collected on 31st October 2016.

MVE virus and WNV_{KUN} Surveillance

Northern mosquito surveillance: In 2016/17, mosquito surveillance was undertaken in the Kimberley and Pilbara regions of WA between 15th March to 13th April 2017. The mosquitoes will be identified to species level in the laboratory and tested for arobviruses during 2017/18.

Sentinel Chicken Program: The level of flavivirus activity in sentinel chickens in northern WA in 2016/17 was increased from the preceding four years. Seroconversions were detected in 128 of the 3807 samples tested (3.36%) with the Kimberley and Pilbara regions experiencing the most activity (Table 8).

Aerial Larviciding Program:

The Department of Health spent $582,529.61 (including contractor retainer cost) in the provision of aerial larviciding treatments through procurement of helicopter services in the Southwest region. A total of 39 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 $237,880.86 to Local Governments (LGs) within CLAGs to assist with the management of mosquitoes and mosquito-borne diseases during 2016/17.

Funding Initiative for Mosquito Management in Western Australia (FIMMWA): The following funding was allocated through FIMMWA in 2016/17 to the following three branches:

- $284,918.67 was directly provided to LG to assist with mosquito management, resources and capacity building;
- $183,971.00 was distributed to research institutions and other bodies for successful research grant applications; and
- $530,000.00 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) yellow fever;
5) chikungunya; and
6) 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 2016/17 was 1115. At the start of the financial year, the number of RRV cases notified to the Department of Health was significantly less than the monthly 5 year moving average (July to November 2016) – Figure 1. During this part of the season, predominant weather patterns were not conducive to mosquito breeding leading to lower mosquito abundance across much of the State and thus, a reduced incidence of disease transmission. However, following heavy rainfall across most of the state in February, the peak of the season occurred in March with significant increases in mosquito populations and also virus activity.

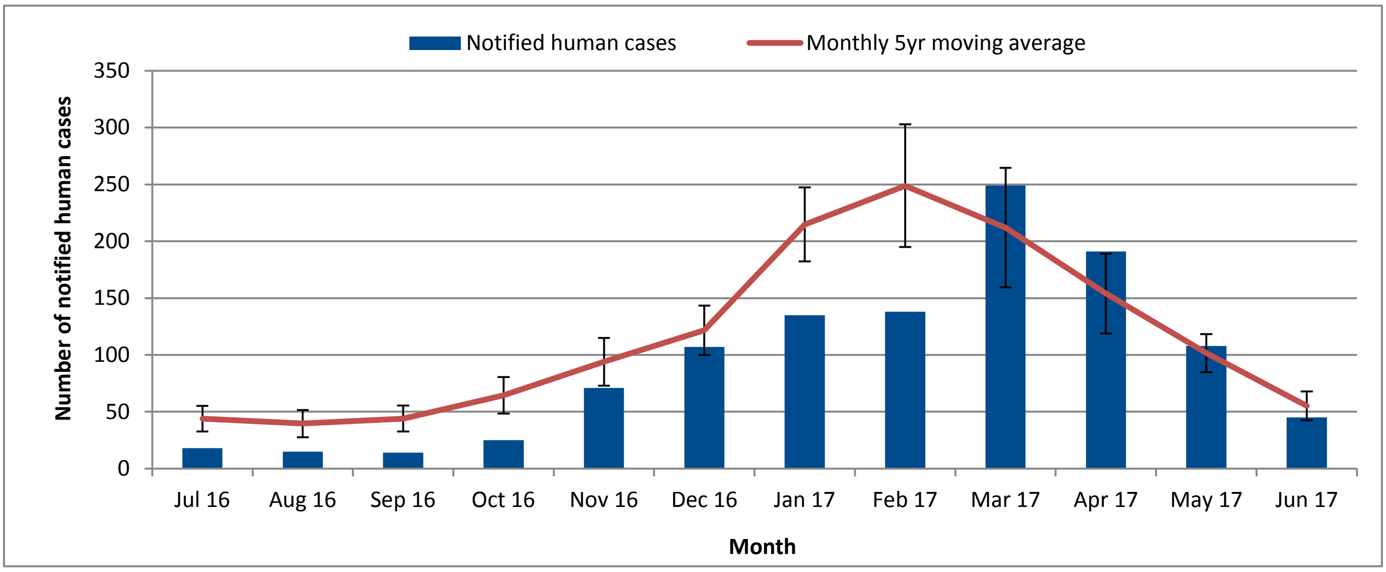


Figure 1: The total number of notified human cases of RRV per month across WA from July 2016 to June 2017*.

**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 – 90 years). Age and sex specific case numbers were highest among females and males of the same age group 45–49 years (Figure 2).

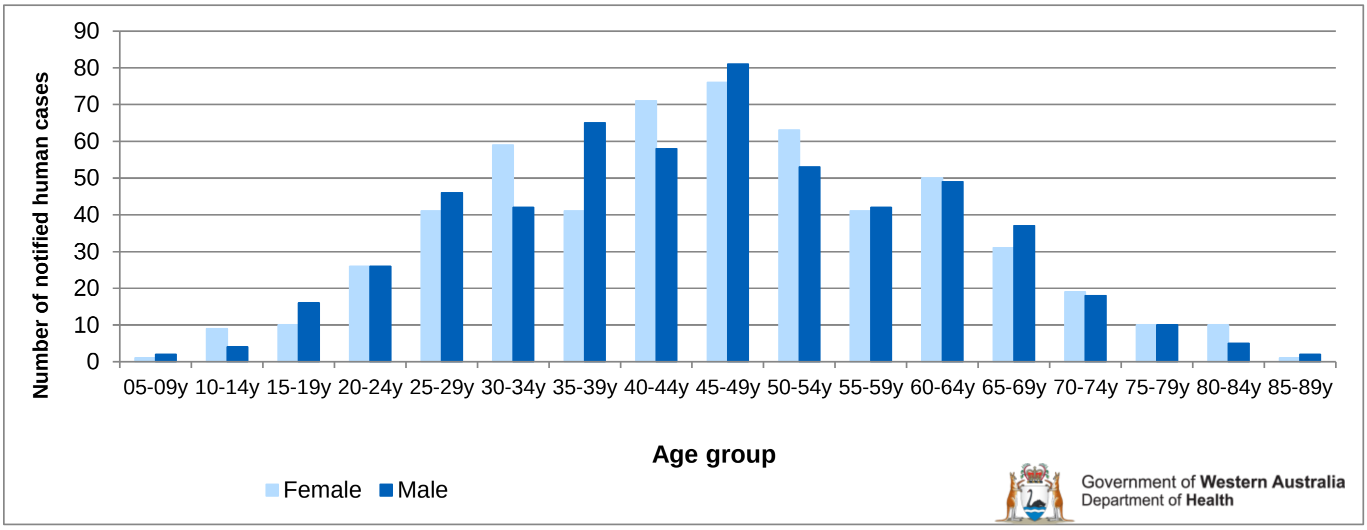


Figure 2: The total number of notified human cases of RRV across WA, by age group and sex from July 2016 to June 2017.

**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 331. 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). With the exception of December, April and May, all other months were close to or below the long term average (Figure 3).

A total of 350 cases were recorded from the Southwest region. The number of cases reported in December, March, April and May were above the monthly five year moving average, with other months having a total below 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 278.8 and ASR of 292.5 were recorded from the Kimberley region for the 2016/17 financial year. This was due to a RRV outbreak in the west Kimberley region in early 2017. Heavy rainfall that occurred over most of the state in February also resulted in small RRV outbreaks in other regions such as Kimberley and Goldfields.

Table 1: Serologically confirmed, doctor-notified, and laboratory reported cases of Ross River virus disease per month for each WA region from July 2016 to June 2017. 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	1	1	1	1	1	0	8	18	55	14	7	2	109	278.8	292.5
Pilbara	0	1	0	0	0	3	2	8	24	10	4	1	53	78.5	76.6
Gascoyne	0	0	0	0	1	0	0	0	3	1	1	0	6	60.2	60.7
Midwest	1	0	0	0	6	2	1	4	4	5	2	2	27	41.4	42.4
Wheatbelt	1	0	0	3	9	3	9	5	15	22	16	7	90	128.2	120.0
Metro	6	7	2	8	10	17	45	48	51	72	43	22	331	19.5	19.1
Southwest	8	4	7	10	34	64	57	42	54	37	24	9	350	82.1	
Peel	1	3	4	3	16	19	14	19	26	24	14	7	150	59.5	58.0
Leschenault	4	0	2	2	4	12	9	8	10	4	3	0	58	78.6	79.0
Geographe	3	1	1	5	11	28	21	11	12	5	5	1	104	197.6	199.7
Elsewhere SW	0	0	0	0	3	5	13	3	6	4	2	1	37	79.8	78.5
Great Southern	1	1	2	1	1	8	12	10	8	4	2	0	50	83.4	83.0
Goldfields-Esperance	0	1	2	2	9	10	1	3	35	26	9	2	100	163.0	158.0
WA undetermined	0	0	0	0	0	0	0	0	0	0	0	0	0		
Interstate	0	1	1	2	0	1	2	0	1	3	0	1	12		
WA Total (Does Not Include Interstate)	**18**	**15**	**14**	**25**	**71**	**107**	**135**	**138**	**249**	**191**	**108**	**45**	**1115**		

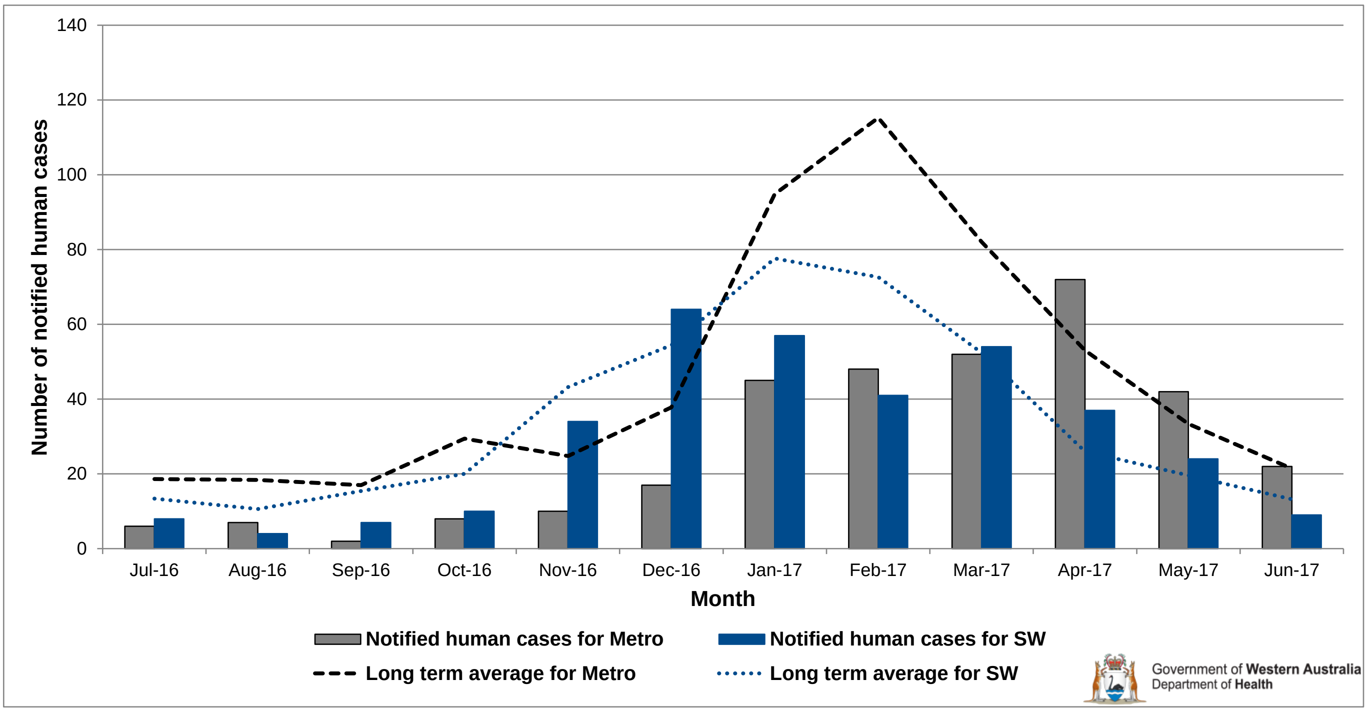


Figure 3: The total number of notified human cases of RRV per month across Metro (Grey) and Southwest (SW-Blue) regions from July 2016 to June 2017*.

**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 2016/17, most LGs reported similar rates of RRV disease compared to the State average (Figure 4). Only 26 of 140 LGs had significantly higher rates compared to the State average, including northern LGs such as Broome, Derby/West Kimberley, parts of the Goldfields and along the south-west and south coasts (Figure 4). Most LGs within the Perth metropolitan region had significantly lower RRV rates compared to the State average, in addition to the City of Greater Geraldton and the Town of Port Hedland.

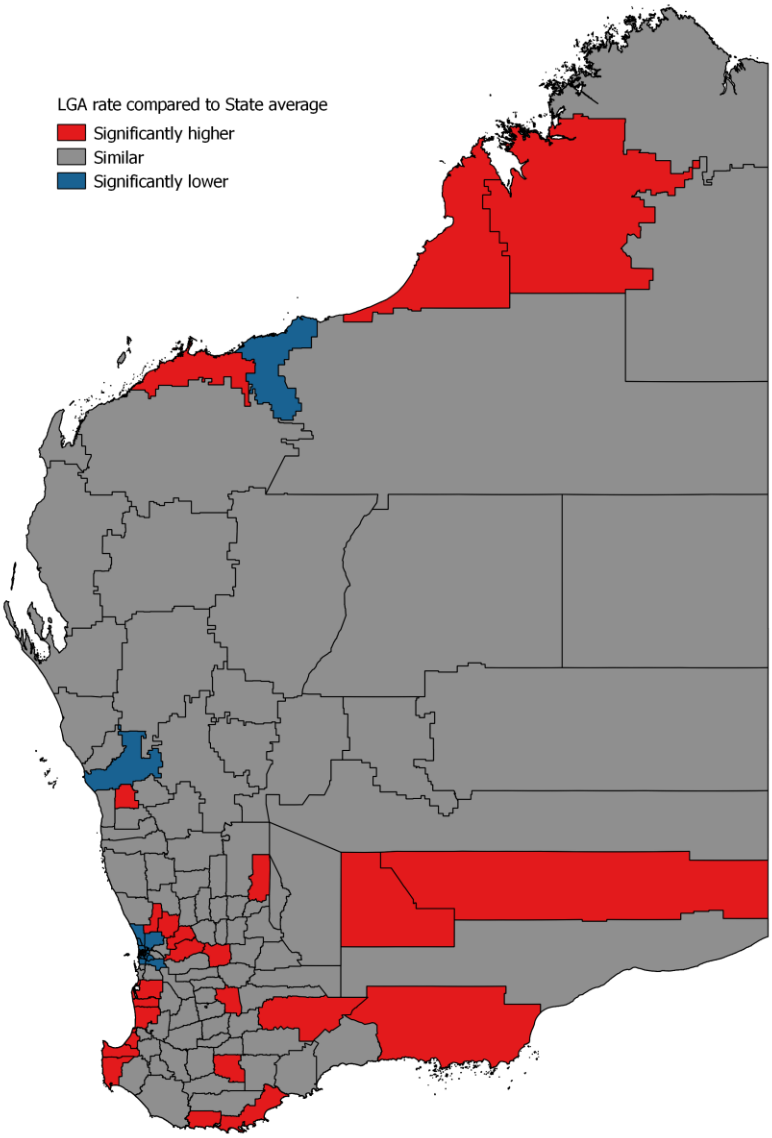


Figure 4: Map of WA showing Local Government areas with rates of human cases of RRV per 100,000 population in 2016/17 that were significantly higher, lower or similar compared to the State average rate.

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).

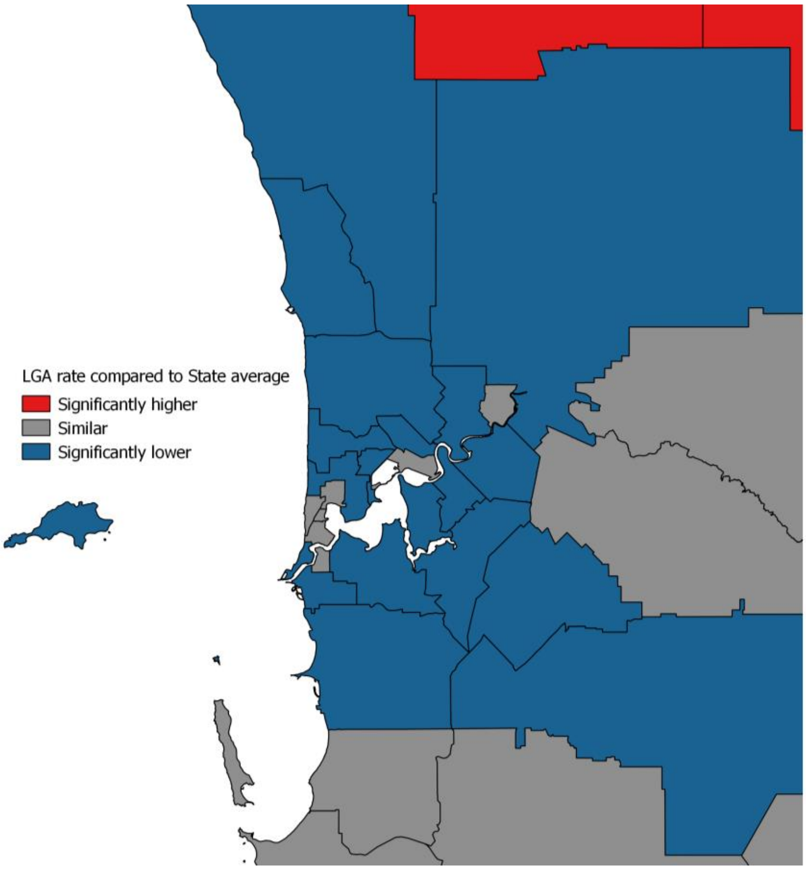


Figure 5: Map of the Perth metropolitan area showing Local Government areas shaded to indicate the rate of human cases of RRV per 100,000 population in 2016/17 compared to the State average rate.

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 is less common 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 of 33 human cases of BFV were notified in WA for 2016/17. The number of cases reported between July and January were less than the monthly average recorded since January 2014; while case numbers in April, May and June 2017 were close to the average and February and March were above (Figure 6).

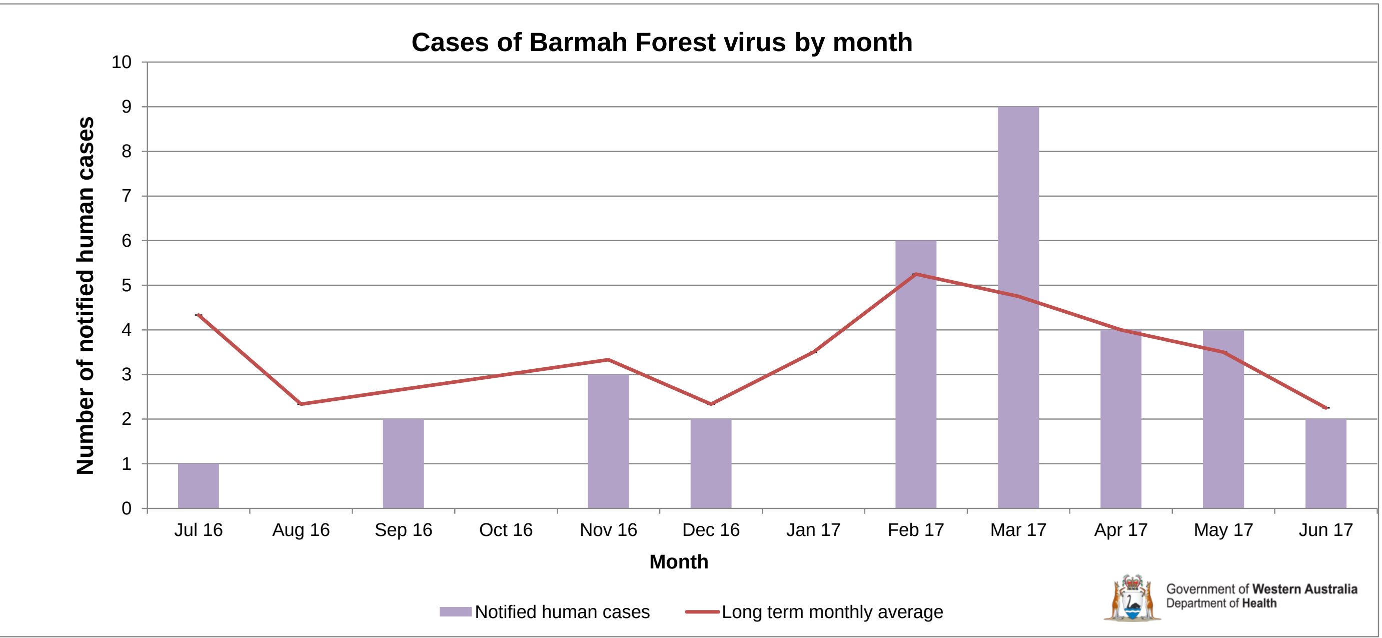


Figure 6: The total number of monthly notified human cases of BFV across WA from July 2016 to June 2017*.

**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

BFV cases were fairly evenly distributed through age groups (median 47 years, range 15 – 79 years). Age and sex specific case numbers were highest among males aged 45 – 49 years, and females aged 35 – 39 years (Figure 7).

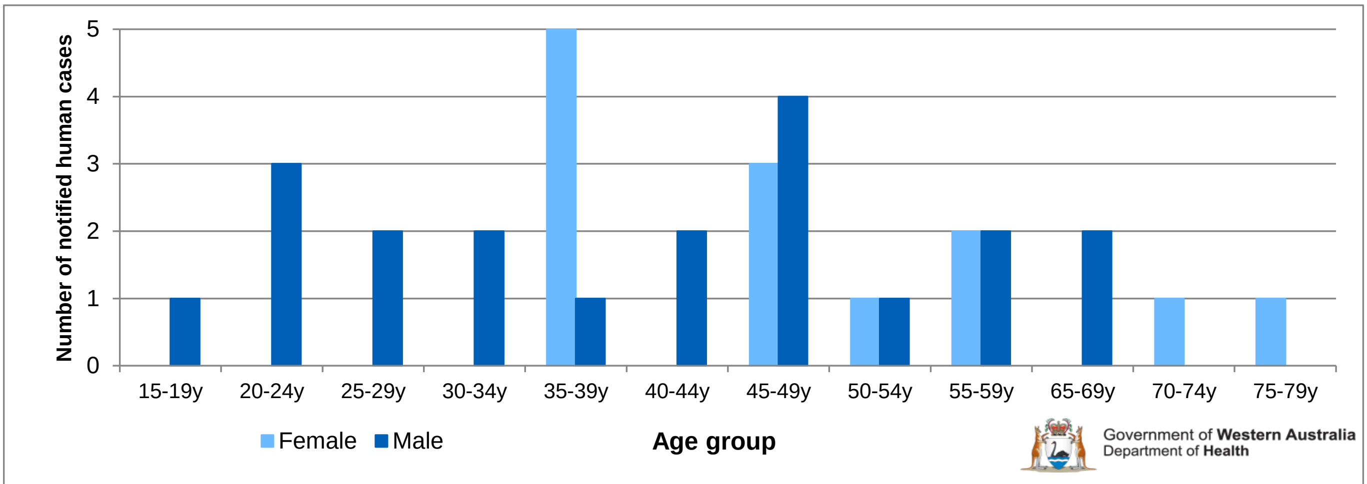


Figure 7: The total number of notified human cases of BFV across WA, by age group and sex from July 2016 to June 2017*.

**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 rate of 22.5 cases 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 2016 to June 2017. CR = Crude rate per 100,000 population. ASR= Age standardised rate (standardised to 2001 Australian standard population)*. Blank cells = '0'.

**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								2	3	2		2	9	23.0	22.5
Pilbara								1	2	2	2		7	10.4	8.7
Gascoyne													0	0	0
Midwest													0	0	0
Wheatbelt			1			1							2	2.8	2.5
Metro	1							1	2		1		5	0.3	0.3
Southwest			1		3	1		1	1		1		8	1.9	0
Peel					2	1					1		4	1.6	1.4
Leschenault					1								1	1.3	1.3
Geographe													0	0	0
Elsewhere SW			1					1	1				3	6.5	7.0
Great Southern								1					1	1.7	2.3
Goldfields-Esperance									1				1	1.6	1.6
WA undetermined													0	0	0
Interstate													0	0	0
WA Total (Does Not Include Interstate)	**1**	**0**	**2**	**0**	**3**	**2**	**0**	**6**	**9**	**4**	**4**	**2**	**33**		

Murray Valley encephalitis (MVE)

The rare but potentially fatal MVE virus is endemic in the Kimberley region and epidemics can at times extend further into the Pilbara 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 severe MVE infections 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.

There was one unconfirmed human case of MVE notified to the Department of Health (DoH) during 2016/17 (Figure 8) from the Kimberley region (Broome). At the time of this report, the case was yet to be confirmed by repeat serological testing. The last confirmed case of MVE in WA occurred in May 2011. A large number of cases (9) were notified to the DoH during 2010/11.

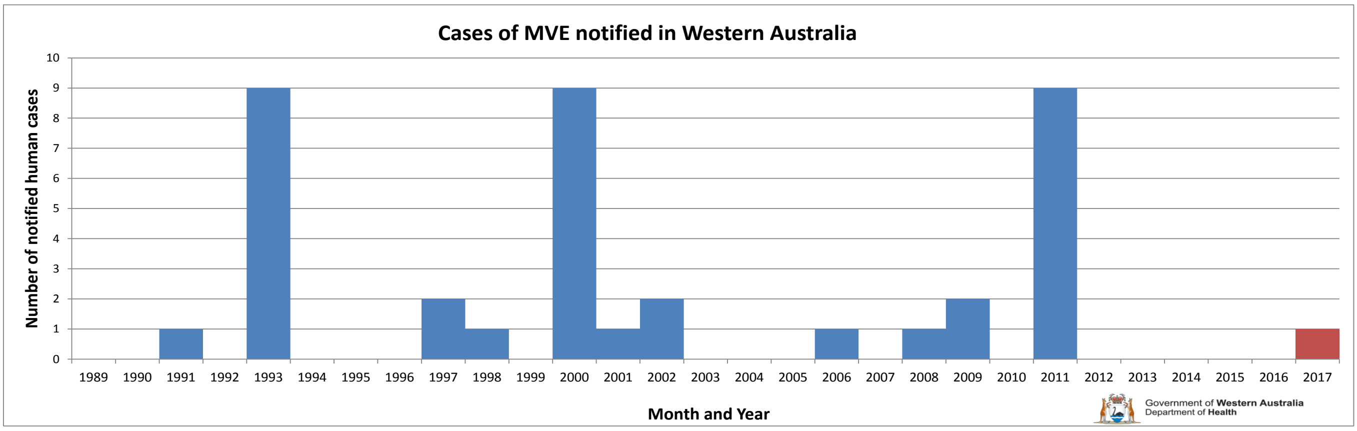


Figure 8: The number of notified human cases of MVE disease occurring in WA since 1989. The red bar in 2017 shows the current unconfirmed case from the 2016-2017 season.

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, the symptoms of the disease are very similar to, but generally milder than MVE. Kunjin disease can also be associated with joint pain.

There were four confirmed human cases of Kunjin disease notified to the DoH in 2016/17 from the Kimberley region (Broome) (Table 3). Additionally, there was one unconfirmed case also notified from the Broome area during this season. At the time of this report, this case was yet to be confirmed after follow-up serological testing. The previous confirmed case of Kunjin disease in WA was reported in 2006 (Figure 9).

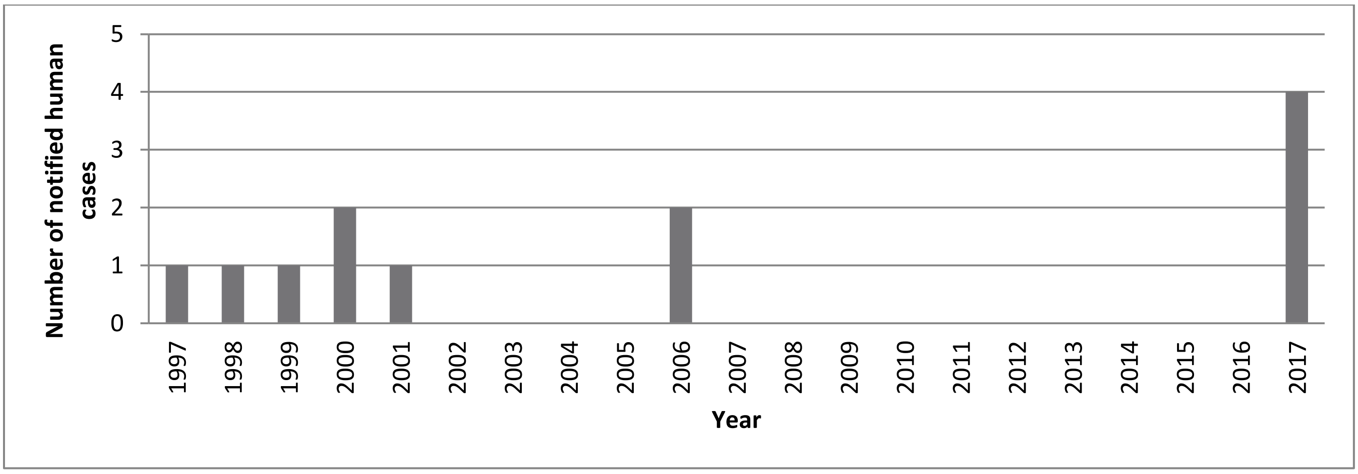


Figure 9: The number of notified (confirmed) human cases of Kunjin disease in WA since 1997. The red bar in 2017 shows the one unconfirmed human case that was notified in the 2016-2017 season.

Table 3: Summary table of confirmed and unconfirmed cases of Kunjin and MVE disease notified to Department of Health during the 2016-17 year.

Exposure Locality	ODOO	Disease	Confirmed/ Unconfirmed case
Broome	17/4/17	Kunjin	C
Broome	5/5/17	Kunjin	C
Broome	24/4/17	Kunjin	C
Broome	19/6/17	Kunjin	C
Broome	2/5/17	MVE	U

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 severe dengue. Severe dengue can include dengue haemorrhagic fever and dengue shock syndrome which can result 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 are not established in WA.

The total number of dengue cases notified in WA during 2016/17 was 304. All cases reported during 2016/17 were acquired overseas.

The number of dengue cases acquired from overseas has declined in general over the last year, particularly those acquired in Bali, Indonesia. There appears to be an increase in dengue being acquired in a greater number of countries included in the 'Elsewhere' category which are outside Indonesia and Thailand (Figure 10).

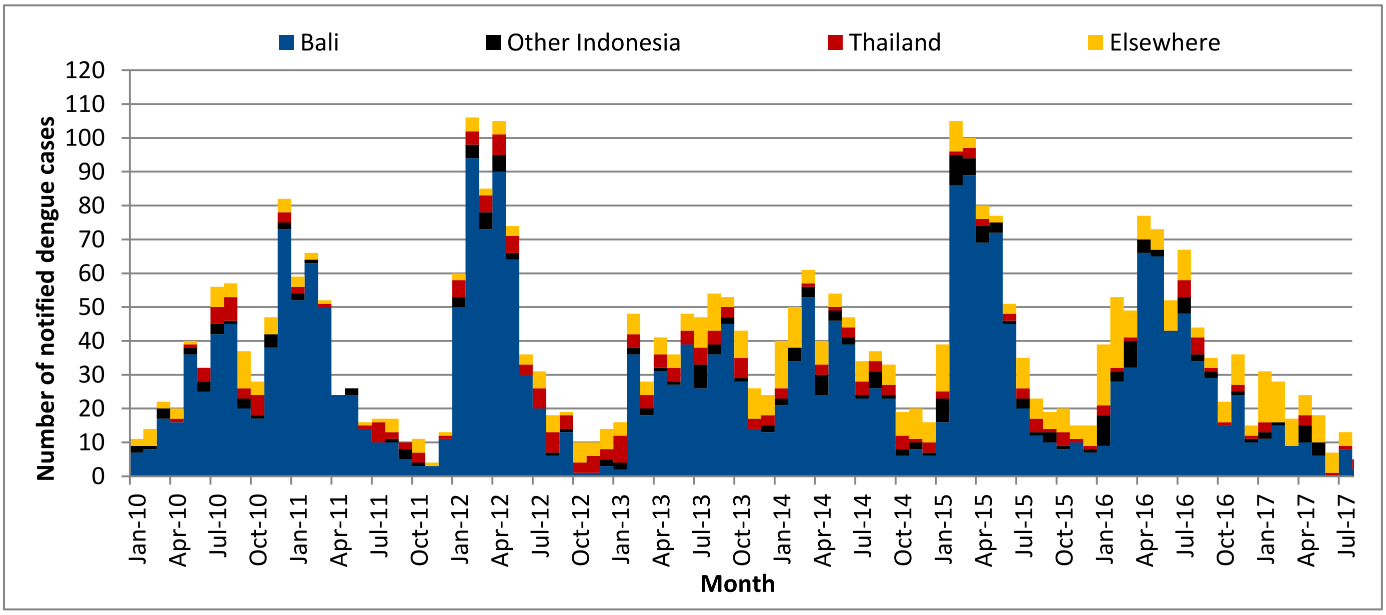


Figure 10: Monthly total number of notified cases of dengue reported in WA but acquired from overseas travel, since 2010.

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 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 18 cases of chikungunya were notified in WA during 2016/17 (Figure 11), which represents an increase in cases entering WA from overseas locations compared to the previous year.

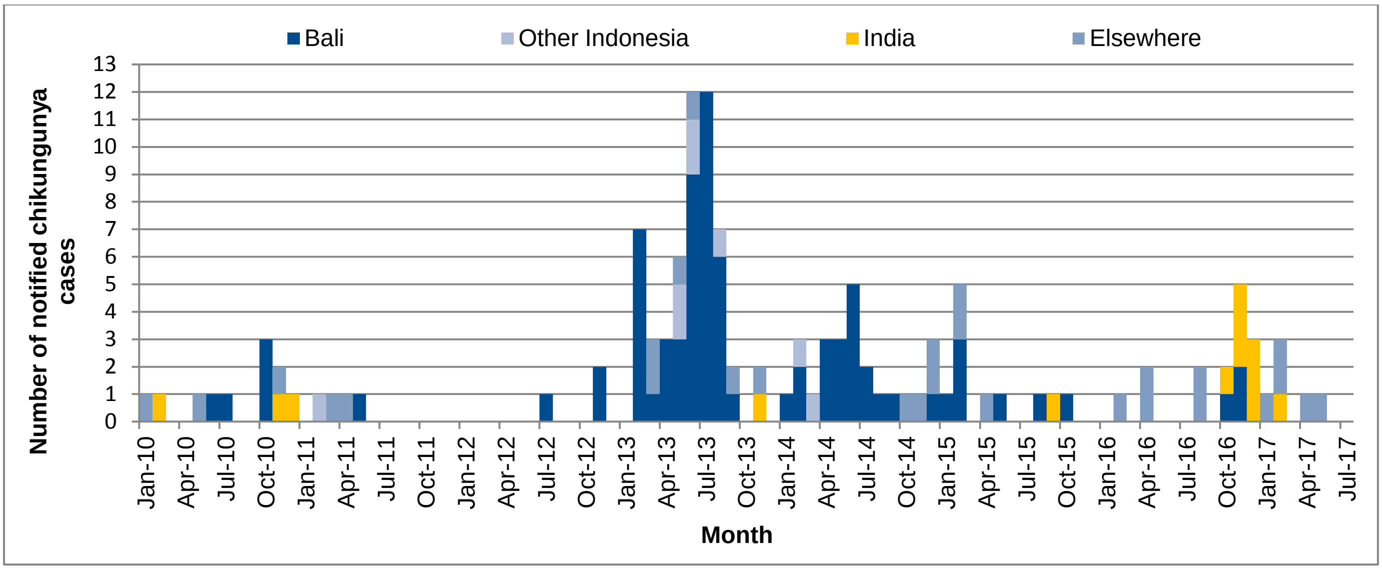


Figure 11: Monthly total number of human notifications of chikungunya reported in WA but acquired from overseas locations, since 2010.

Zika

Zika virus causes an illness known as Zika virus disease which includes 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. Since this recent spread, Zika virus cases have been diagnosed in WA (Figure 13).

Eight overseas acquired cases of Zika virus disease were reported in WA in 2016/17.

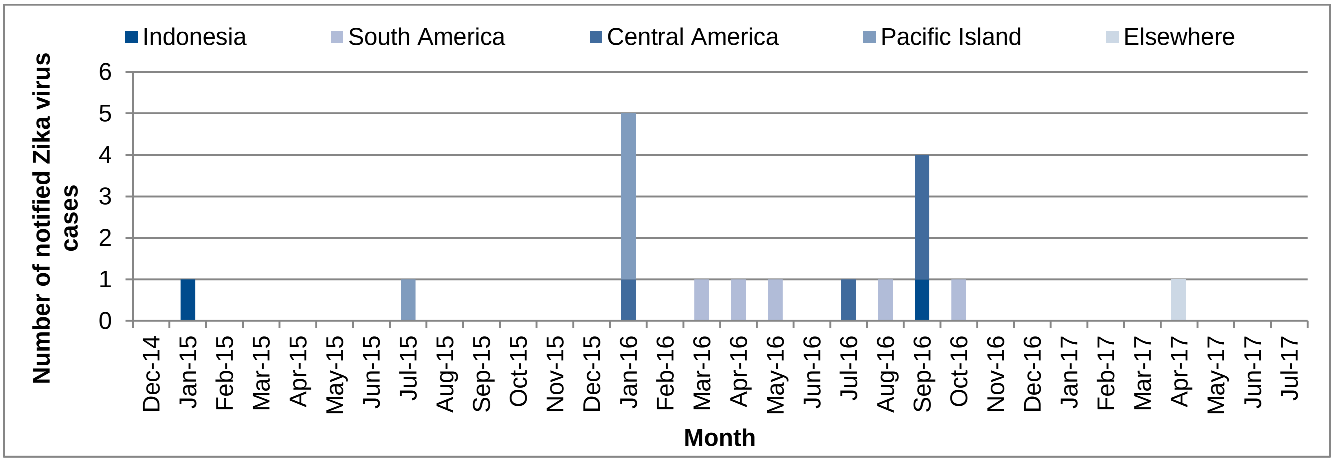


Figure 13: Monthly total number of notifications of Zika virus disease reported in WA but acquired from overseas locations, since 2014.

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 2016/17 was 68 (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).

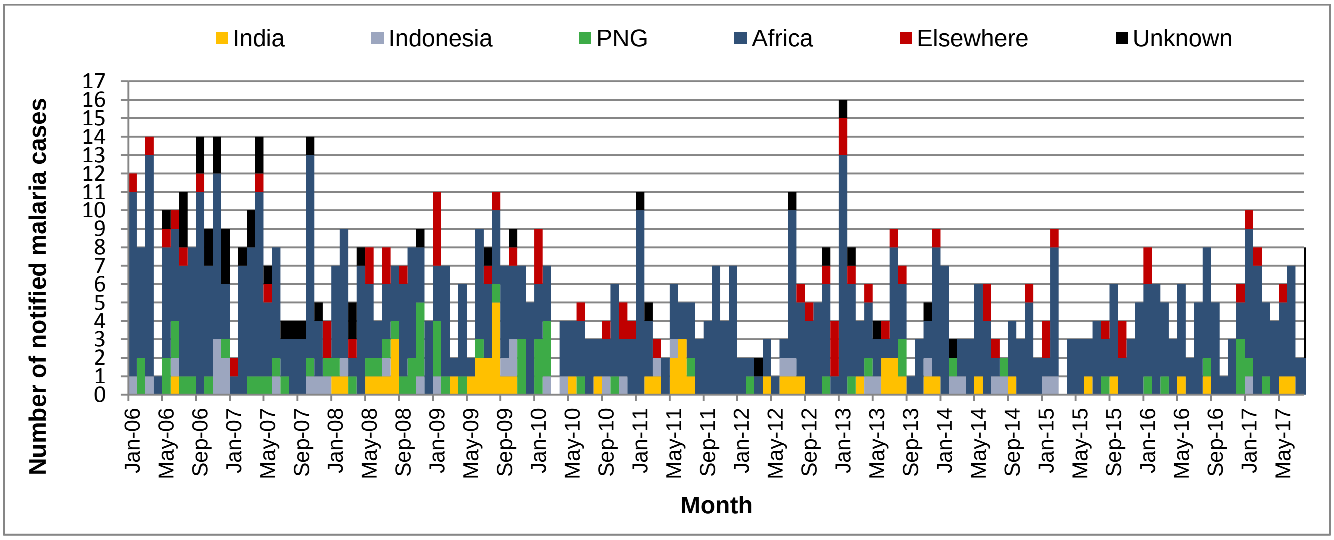


Figure 12: Monthly total number of notifications of Malaria reported in WA but acquired from overseas locations, since 2006.

Climatic Conditions 2016/17

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. 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.

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. The presence of predominantly neutral conditions during 2016/17 (Figure 14) was associated an increase in mosquito breeding compared to the previous year which experienced El Niño conditions and very low mosquito breeding. This increase in mosquito breeding resulted in a return to average mosquito populations and virus activity. The Figure 14 shows the presence of a consistent neutral pattern from October to May. September was the only month that moved into a La Niña pattern (above +7) and June was the only month that moved into an El Niño pattern.

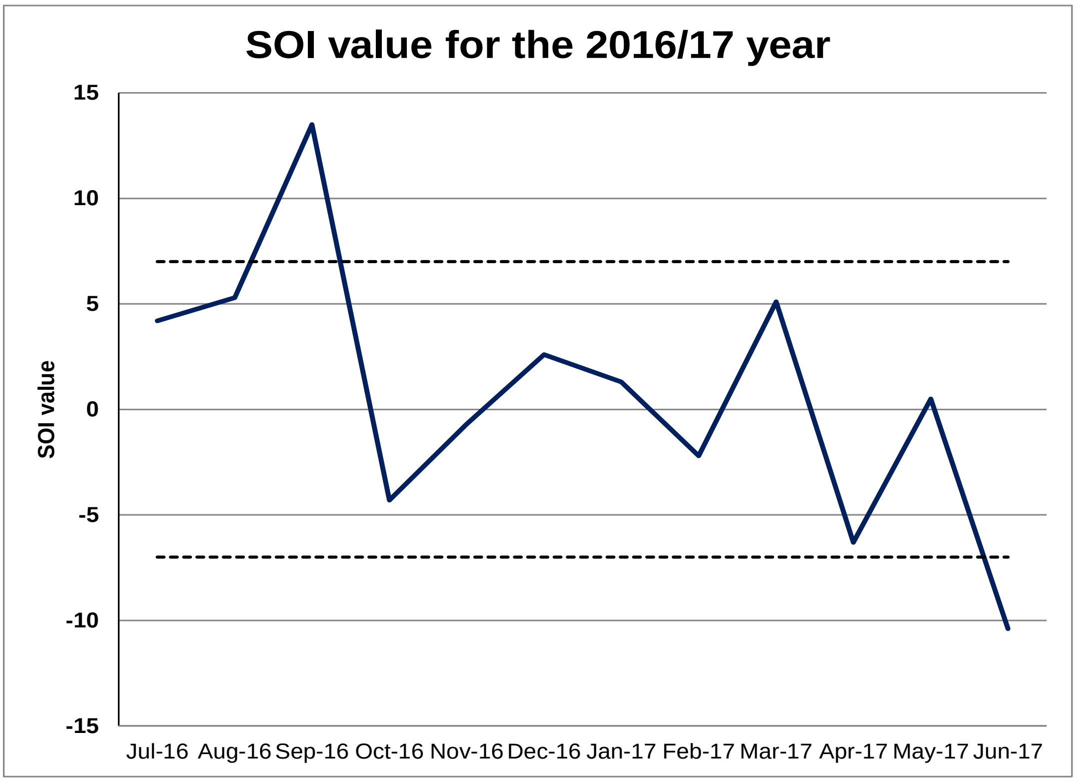
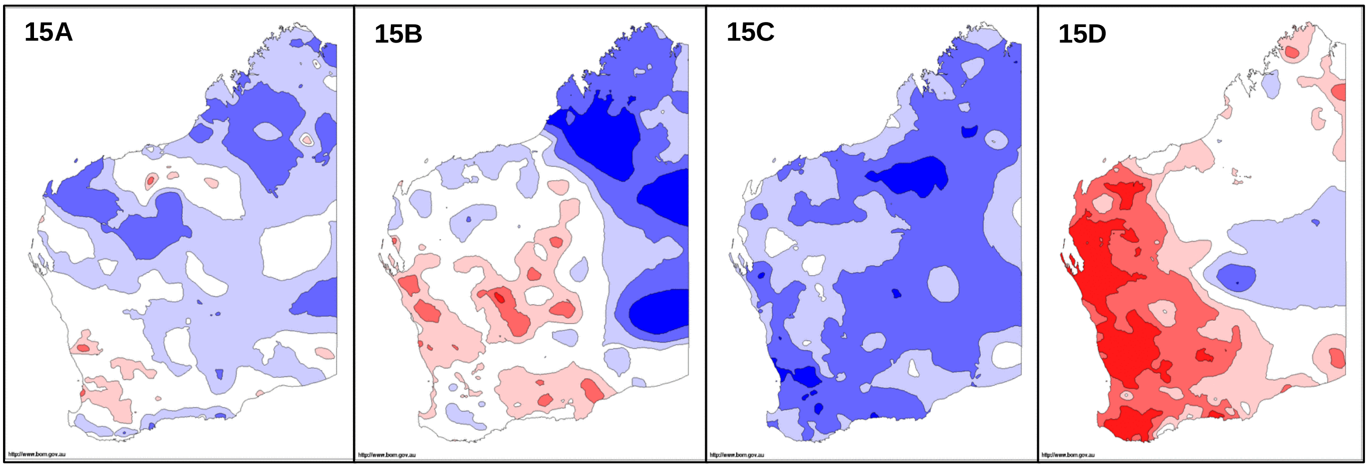
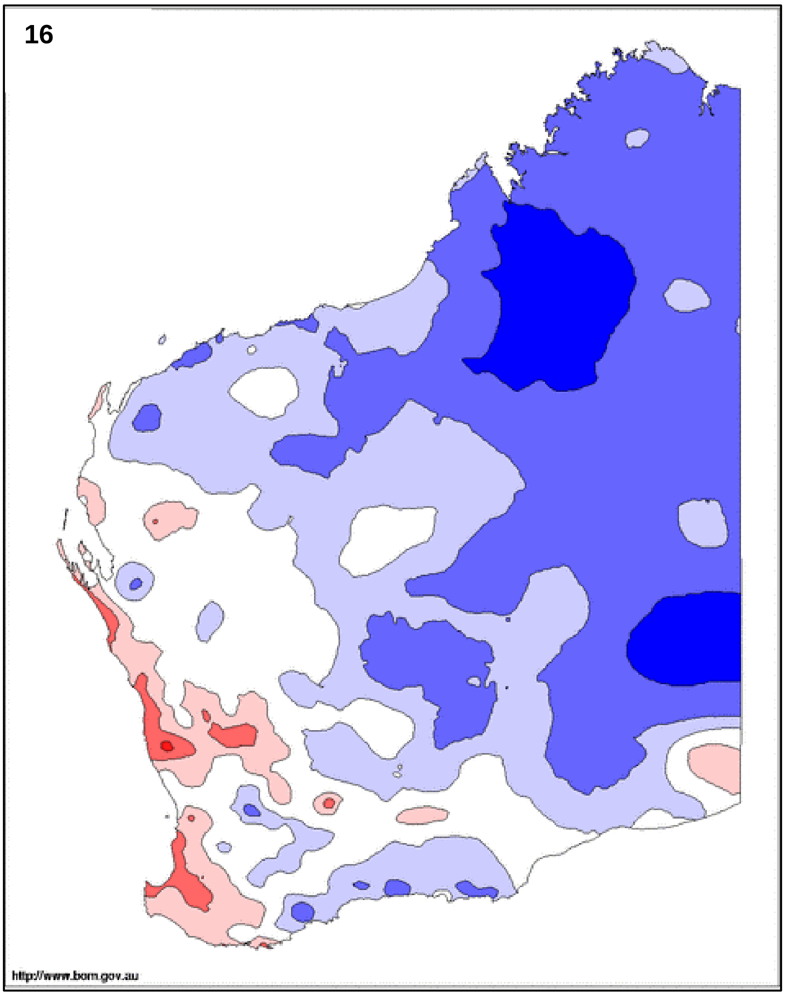


Figure 14: Southern Oscillation Index values (SOI) for the 2016/17 financial year (source: Commonwealth Bureau of Meteorology).
*Sustained positive values of the SOI above +7 typically indicate La Niña while sustained negative values below −7 typically indicate El Niño. Values between about +7 and −7 generally indicate neutral conditions. Dotted lines are at both +7 and -7.

Rainfall

Rainfall was average to very much above average for the majority of the interior parts of WA. Heavy rainfall occurred from December through to March for most of the state, however the regions with highest rainfall amounts were the Kimberley and interior regions. The South West was the only region to receive below to average amounts of rainfall during 2016-2017 (Figures 16-17).





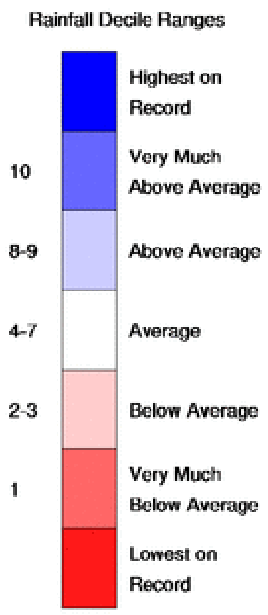


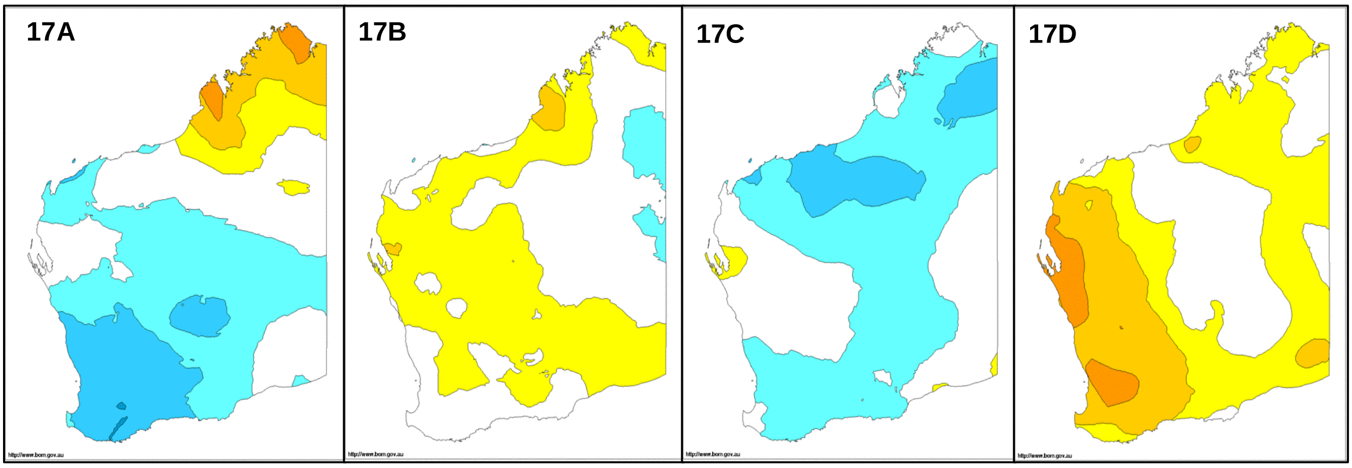
Figure 15 A-D: Three-monthly summary of Western Australian rainfall deciles. A: July-September 2016; B: October-December 2016; C: January-March 2017; D: April-June 2017 (source: Commonwealth Bureau of Meteorology).

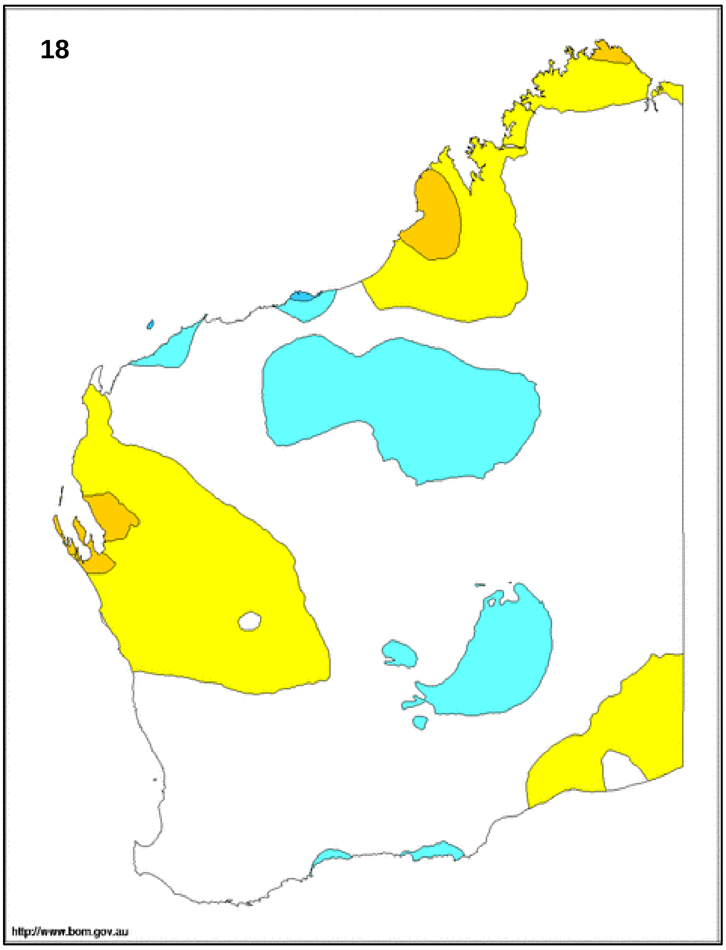
Figure 16: Western Australian Rainfall deciles for July 2016-June 2017 (source: Commonwealth Bureau of Meteorology).

Temperature

Maximum Temperature

Maximum temperatures were close to average for most parts of the state during the 2016-2017 year (Figures 18-19). However, there were periods when maximum temperatures were below or very much below average for most areas of WA, particularly during winter months in 2016 and summer months in 2017. Conversely, April-June 2017 experienced above average maximum temperatures.





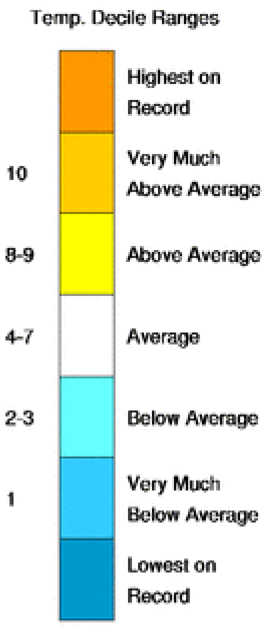


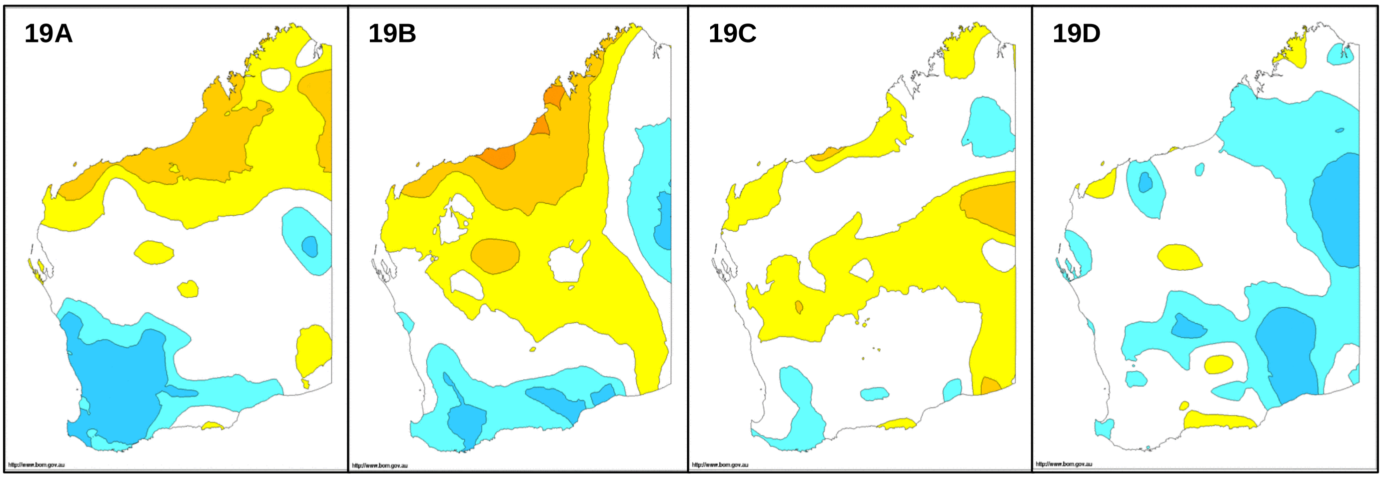
Figure 17 A-D: Three-monthly summaries of Western Australian maximum temperature deciles. A: July-September 2016; B: October-December 2016; C: January-March 2017; D: April-June 2017 (source: Commonwealth Bureau of Meteorology).

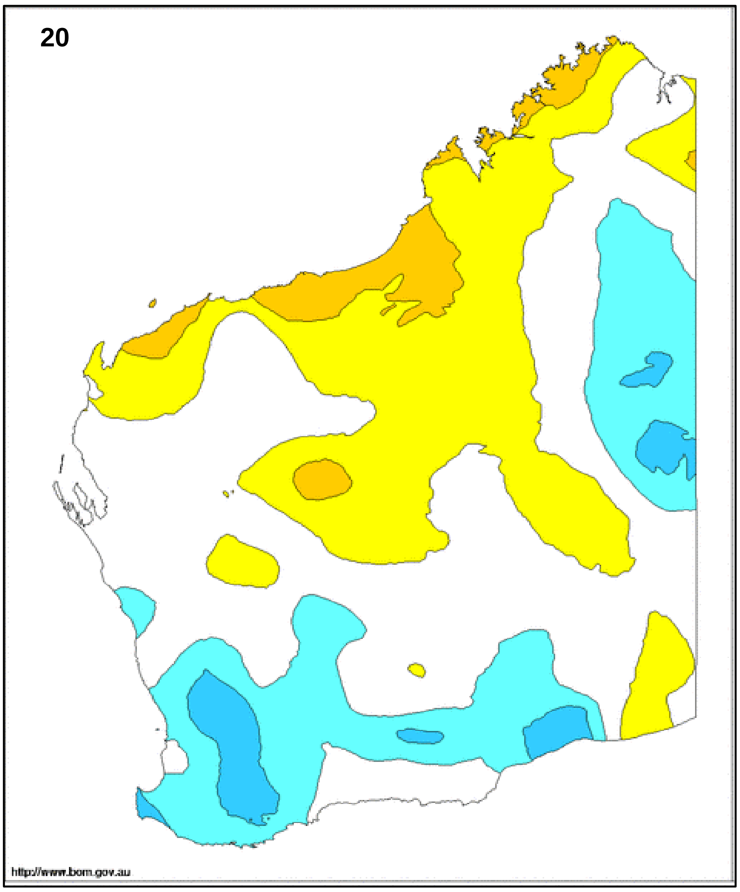
Figure 18: Western Australian maximum temperature deciles for July 2016-June 2017 (source: Commonwealth Bureau of Meteorology).

Minimum Temperature

Minimum temperatures were typically below average in the southern regions of WA and above average in the northern and interior regions during 2016/17 (Figures 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. Warmer temperatures also enable arboviruses to replicate at a higher rate in the vector mosquitoes.





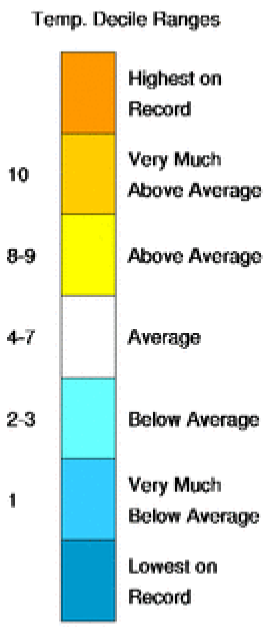


Figure 19 A-D: Three-monthly summaries of Western Australian minimum temperature deciles. A: July-September 2016; B: October-December 2016; C: January-March 2017; D: April-June 2017 (source: Commonwealth Bureau of Meteorology).

Figure 20: Western Australian minimum temperature deciles for July 2016-June 2017 (source: Commonwealth Bureau of Meteorology).

2016/17 Australian Tropical Cyclone Season Summary

The only tropical cyclone to cross WA coastline during 2016-2017 was TC Yvette although there was little impact on WA mainland other than some areas in the Kimberley of heavy rainfall in late December and early January. However, there were also two major tropical low systems that did affect various WA regions in the early months of 2017.

Tropical Low 14U

A tropical low crossed into Western Australia (in the vicinity of Kununurra) from the Northern Territory during the morning of 25 January. The low tracked towards the west and was located near Kuri Bay during the morning of 26 January. The heaviest 24 hour rainfall recorded to 9am was 177mm at El Questro (25 January), 93mm at Mount Rob (26 January) and 95mm at Country Downs (27 January). The low then tracked towards the west southwest and moved offshore, north of Broome, late on 26 January (Figure 21).

Following the heavy rainfall, the Fitzroy River at Fitzroy Crossing peaked above 8 metres, below the minor flood level (9.5 m). Downstream of Fitzroy Crossing, Noonkanbah and Willare approached the minor flood class levels. Significant river rises occurred in the Kimberley. Minor to moderate flooding occurred in the Ord River at Tarrara Bar, Flying Fox Hole. The King River at Cockburn North peaked above the major flood level (3.0 m). River rises up to 7.0 metres were recorded in the Dunham River at Dunham Gorge. River rises were also observed in the upper Ord River catchment. Higher than normal tides were recorded along the Pilbara coast, with a storm surge of around 0.5m being recorded at several locations.

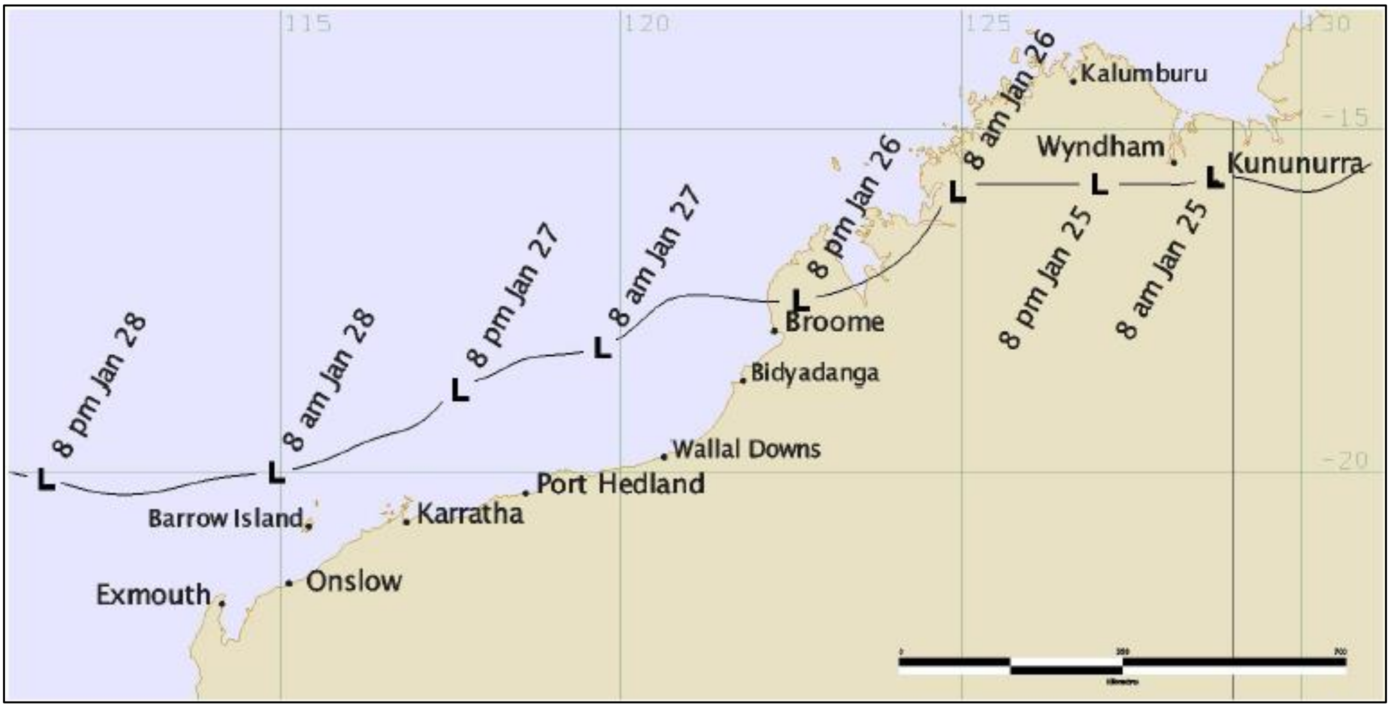


Figure 21: Documented path of Tropical Low 14U National Climate Centre, Commonwealth of Australia, Bureau of Meteorology.

Tropical Low 22U

A tropical low (22U) developed to the northwest of Western Australia on 20 and 21 March. The low tracked generally towards the south and approached the Pilbara coast on 22 March. During 23 March, the system developed and crossed the coast just to the west of Port Hedland during the early afternoon (Figure 22).

The system and associated cloud band produced heavy rainfall in the Pilbara and central Western Australia between the 21 and 25 March. The following 24 hour rainfall totals were recorded during this time:

- Port Hedland Airport – 103.2mm.
- Port Hedland Airport – 105.2mm.
- Newman Aerodrome – 93.4mm,
- Port Hedland Airport - 69.8mm.
- Leonora Aerodrome – 91.8mm,
- Laverton Aerodrome – 57.8mm.

Significant river rises occurred in the Pilbara coastal rivers, De Grey River and Fortescue River. The Fortescue River at Newman peaked at around 3.5 metres (close to the minor flood level of 4 metres) and minor flooding was recorded in the Yule River. Minor to major flooding was observed at some locations in the De Grey River catchment.

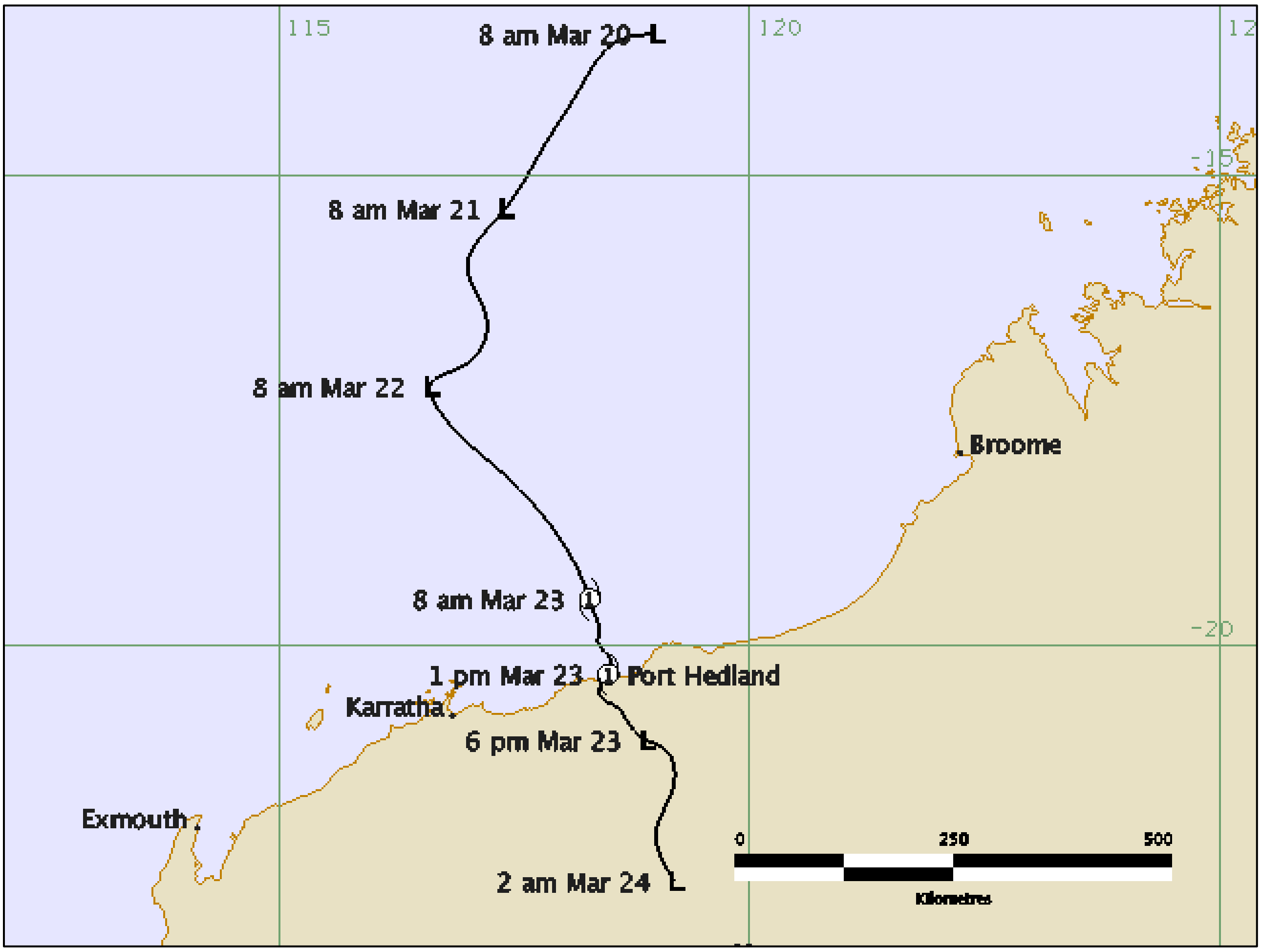


Figure 22: Documented path of Tropical Low 22U National Climate Centre, Commonwealth of Australia, Bureau of Meteorology.

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 neutral weather conditions contributed to mosquito abundance similar (although lower) to long term mosquito abundance across the Southwest (Figure 23). The dominant species collected around Peel were *Aedes camptorhynchus*, *Ae. notoscriptus and Ae.vigilax* (Table 4). *Aedes camptorhynchus* and the spring species *Ae. clelandi* and *Ae. hesperonotius* were the dominant species at sites further south (Table 5-8). High numbers of *Ae. vigilax* are usually observed from December onward, however this did not occur during the 2016/17 summer (Figure 24).

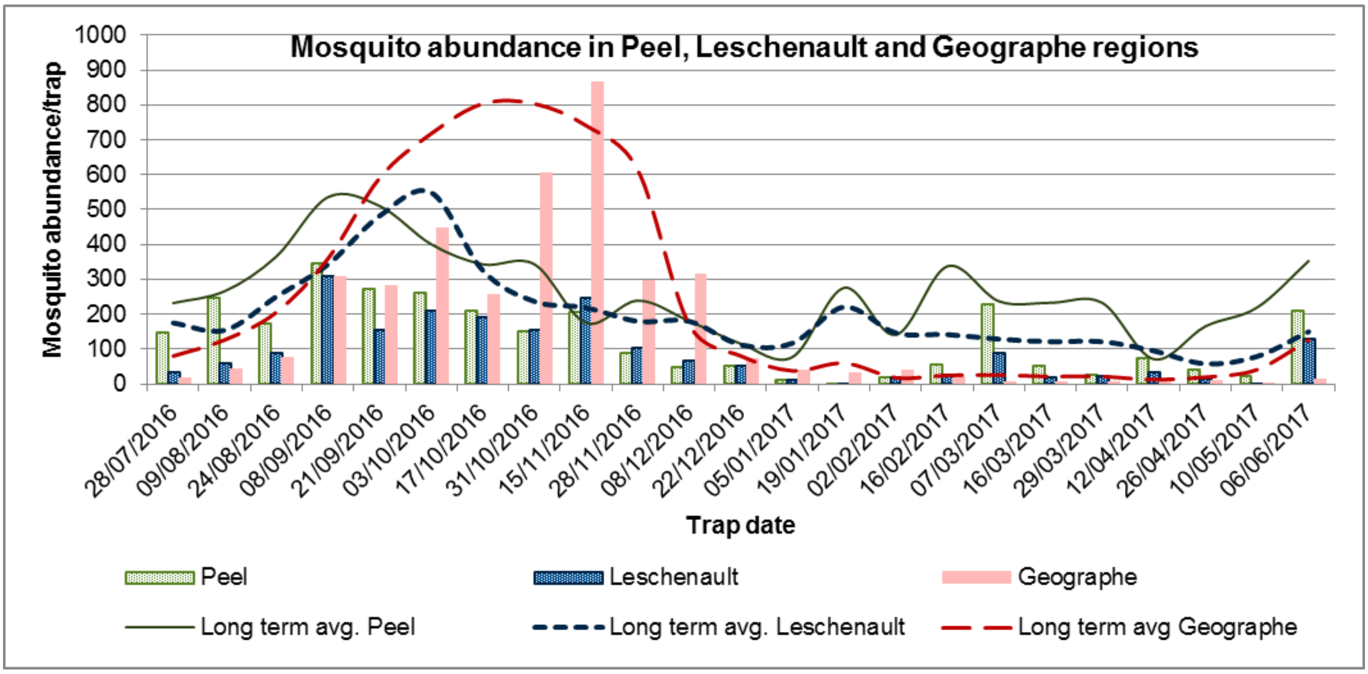


Figure 23: Mosquito abundance in Peel, Leschenault and Geographe in Southwest region of WA from July 2015 to June 2016.

For this season, a total of 61,948 mosquitoes were collected from fortnightly trapping at 21 sites across the Southwest of Western Australia (Table 4-8). There were 496 traps set in the Southwest of which 451 traps were successful (91%).

Ross River virus was detected at 10 of the 21 routine surveillance sites in the Southwest of WA. Detections ranged from the most northerly site at Lake Goegrup on 8th September 2016 to the most southerly site at Quindalup on 28th November 2016. There were 38 real-time RT-PCR detections of RRV from pools of *Ae. camptorhynchus* (25), *Ae. hesperonotius* (5), *Ae. alboannulatus* (3), *Ae. clelandi* (1), *Ae. notoscriptus* (1), *Coquillettidia linealis* (1), *Cx. globocoxitus* (1) and *Culex* sp. male (1). BFV was detected at one of the routine surveillance sites in the Southwest at Lake Goegrup on 31st October 2016 from a pool of *Ae. camptorhynchus* (Table 4).

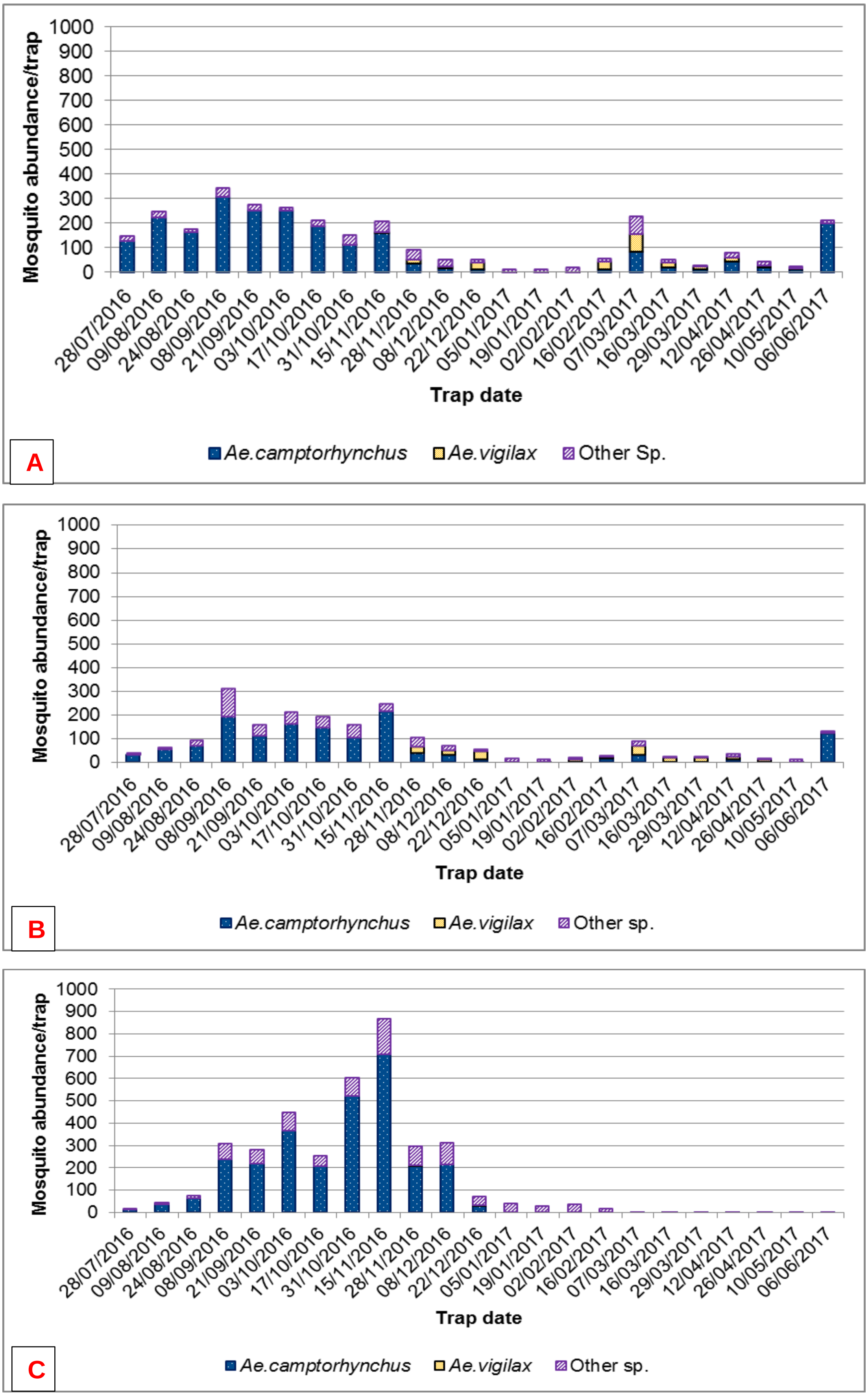


Figure 24: *Ae camptorhynchus, Ae vigilax* and all other species collected per trap for **A**: Peel **B**: Leschenault and **C**: Geographe regions of WA from July 2016 to June 2017

Table 4: Details of mosquitoes collected and processed for virus isolation, Peel inlet, southwest of Western Australia, 1 July 2016 to 30 June 2017.

Species	Total	%	Processed	Pool count	Pinned	Virus	MIR
Ae. (Finlaya) alboannulatus	**578**	**2.76**	**546**	**90**	**0**		
Bloodfed	3	0.01	0	0	0		
Female	575	**2.75**	546	90	0		
Ae. (Finlaya) notoscriptus	**1594**	**7.62**	**1517**	**149**	**0**		
Bloodfed	1	0.00	0	0	0		
Female	1592	7.61	1516	148	0		
Male	1	0.00	1	1	0		
Ae. (Ochlerotatus) camptorhynchus	**15433**	**73.81**	**12367**	**682**	**1**		
Bloodfed	23		0	0	0		
Female	15388	73.60	12348	675	1	3RRV 1BFV	0.2 0.1
Male	22	0.11	19	7	0		
Ae. (Ochlerotatus) clelandi	**1**	**0.00**	**1**	**1**	**0**		
Female	1	0.00	1	1	0		
Ae. (Ochlerotatus) vigilax	**1689**	**8.08**	**1656**	**123**	**0**		
Bloodfed	32	0.15	0	0	0		
Female	1652	7.90	1651	121	0		
Male	5	0.02	5	2	0		
***Ae*. species (unidentified) - new or difficult to ID species**	**3**	**0.01**	**3**	**3**	**0**		
Male	3	0.01	3	3	0		
An. (Cellia) annulipes s.l.	**50**	**0.24**	**48**	**30**	**0**		
Female	49	0.23	47	29	0		
Male	1	0.00	1	1	0		
Cq. (Coquillettidia)* species near *linealis	**1**	**0.00**	**1**	**1**	**0**		
Female	1	0.00	1	1	0		
Cs. (Culicella) atra	**11**	**0.05**	**11**	**7**	**0**		
Female	11	0.05	11	7	0		
Cx. (Culex) annulirostris	**32**	**0.15**	**31**	**19**	**0**		
Female	32	0.15	31	19	0		
Cx. (Culex) australicus	**404**	**1.93**	**387**	**78**	**0**		
Bloodfed	1	0.00	0	0	0		
Female	403	1.93	387	78	0		
Cx. (Culex) globocoxitus	**774**	**3.70**	**753**	**100**	**0**		
Bloodfed	2	0.01	0	0	0		
Female	772	3.69	753	100	0		
Cx. (Culex) quinquefasciatus	**235**	**1.12**	**229**	**53**	**0**		
Bloodfed	1	0.00	0	0	0		
Female	234	1.12	229	53	0		
***Cx*. species (unidentified) - new or difficult to ID species**	**57**	**0.27**	**57**	**22**	**0**		
Male	57	0.27	57	22	0		
Tripteroides (Polylepidomyia) atripes	**2**	**0.01**	**1**	**1**	**1**		
Female	2	0.01	1	1	1		
Unidentifiable (too damaged/features missing)	**1**	**0.00**	**1**	**1**	**0**		
Female	1	0.00	1	1	0		
Unidentifiable *Aedes* sp. (too damaged/features missing)	**11**	**0.05**	**11**	**5**	**0**		
Female	11	0.05	11	5	0		
Unidentifiable *Culex* sp. (too damaged/features missing)	**32**	**0.15**	**31**	**15**	**0**		
Female	28	0.13	27	13	0		
Male	4	0.02	4	2	0		
Grand Total	**20908**	**100**	**17651**	**1380**	**2**	**3RRV 1BFV**	**0.2 0.1**

MIR is minimum infection rate per 1000 mosquitoes (Chiang and Reeves 1962).

Table 5: Details of mosquitoes collected and processed for virus isolation, Harvey Estuary sites, southwest of Western Australia, 1 July 2016 to 30 June 2017.

Species	Total	Processed	%	Pool count	Virus	MIR
Ae. (Finlaya) alboannulatus	**148**	**139**	**2.57**	**24**		
Bloodfed	2	0	0.03	0		
Female	146	139	2.54	24		
Ae. (Finlaya) notoscriptus	**75**	**69**	**1.30**	**21**		
Bloodfed	1	0	0.02	0		
Female	74	69	1.29	21		
Ae. (Ochlerotatus) camptorhynchus	**4714**	**4233**	**81.97**	**231**		
Bloodfed	59	1	1.03	0		
Female	4648	4225	80.82	226		
Male	7	7	0.12	5		
Ae. (Ochlerotatus) clelandi	**4**	**4**	**0.07**	**3**		
Female	4	4	0.07	3		
Ae. (Ochlerotatus) vigilax	**372**	**361**	**6.47**	**26**		
Bloodfed	11	0	0.19	0		
Female	357	357	6.21	25		
Male	4	4	0.07	1		
***Ae*. species (unidentified) - new or difficult to ID species**	**1**	**1**	**0.02**	**1**		
Male	1	1	0.02	1		
An. (Cellia) annulipes s.l.	**306**	**305**	**5.32**	**29**		
Bloodfed	1	0	0.02	0		
Female	301	301	5.23	28		
Male	4	4	0.07	1		
Cq. (Coquillettidia) species near linealis	**13**	**13**	**0.23**	**7**		
Female	13	13	0.23	7		
Cx. (Culex) annulirostris	**6**	**6**	**0.10**	**6**		
Female	6	6	0.10	6		
Cx. (Culex) australicus	**42**	**42**	**0.73**	**11**		
Female	42	42	0.73	11		
Cx. (Culex) globocoxitus	**54**	**54**	**0.94**	**14**		
Female	54	54	0.94	14		
Cx. (Culex) quinquefasciatus	**4**	**4**	**0.07**	**3**		
Female	4	4	0.07	3		
***Cx*. species (unidentified) - new or difficult to ID species**	**5**	**5**	**0.09**	**2**		
Male	5	5	0.09	2		
Unidentifiable *Culex* sp. (too damaged/features missing)	**1**	**1**	**0.02**	**1**		
Female	1	1	0.02	1		
Ae. (Ochlerotatus) ratcliffei	**6**	**6**	**0.10**	**4**		
Female	6	6	0.10	4		
Grand Total	**5751**	**5243**	**100**	**383**		

Table 6: Details of mosquitoes collected and processed for virus isolation, Leschenault, southwest of Western Australia, 1 July 2016 to 30 June 2017. [1]

Species	Total	%	Processed	Pool count	Pinned	Virus	MIR
Ae. (Finlaya) alboannulatus	**623**	4.92	**600**	**95**	**0**		
Female	622	4.91	599	94	0	2RRV	3.4
Male	1	0.01	1	1	0		
Ae. (Finlaya) notoscriptus	**213**	1.68	**205**	**54**	**0**		
Female	213	1.68	205	54	0		
Ae. (Ochlerotatus) camptorhynchus	**8145**	64.27	**6901**	**402**	**1**		
Bloodfed	78	0.62	0	0	0		
Female	8062	63.61	6897	400	1	8RRV	1.2
Male	5	0.04	4	2	0		
Ae. (Ochlerotatus) clelandi	**181**	1.43	**181**	**18**	**0**		
Female	181	1.43	181	18	0		
Ae. (Ochlerotatus) hesperonotius	**1111**	8.77	**987**	**52**	**0**		
Bloodfed	4	0.03	0	0	0		
Female	1107	8.73	987	52	0	4RRV	4.2
Ae. (Ochlerotatus) mackintoshi	**1**	0.01	**0**	**0**	**1**		
Female	1	0.01	0	0	1		
Ae. (Ochlerotatus) nigrithorax	**186**	1.47	**179**	**11**	**6**		
Bloodfed	1	0.01	0	0	0		
Female	185	1.46	179	11	6		
Ae. (Ochlerotatus) ratcliffei	**8**	0.06	**8**	**7**	**0**		
Female	8	0.06	8	7	0		
Ae. (Ochlerotatus) turneri	**3**	0.02	**3**	**2**	**0**		
Female	3	0.02	3	2	0		
Ae. (Ochlerotatus) vigilax	**1251**	9.87	**1240**	**94**	**0**		
Bloodfed	8	0.06	0	0	0		
Female	1242	9.80	1239	93	0		
Male	1	0.01	1	1	0		
***Ae*. species (unidentified) - new or difficult to ID species**	**2**	0.02	**2**	**2**	**0**		
Male	2	0.02	2	2	0		
An. (Anopheles) atratipes	**3**	0.02	**2**	**2**	**0**		
Female	3	0.02	2	2	0		
An. (Cellia) annulipes s.l.	**88**	0.69	**87**	**33**	**0**		
Female	88	0.69	87	33	0		
Cq. (Coquillettidia)* species near *linealis	**71**	0.56	**70**	**24**	**0**		
Bloodfed	1	0.01	0	0	0		
Female	70	0.55	70	24	0	1RRV	14.5
Cs. (Culicella) atra	**26**	0.21	**26**	**12**	**0**		
Female	26	0.21	26	12	0		
Cx. (Culex) annulirostris	**58**	0.46	**58**	**23**	**0**		
Female	58	0.46	58	23	0		
Cx. (Culex) australicus	**286**	2.26	**272**	**51**	**0**		
Female	286	2.26	272	51	0		
Cx. (Culex) globocoxitus	**336**	2.65	**328**	**59**	**0**		
Bloodfed	2	0.02	0	0	0		
Female	334	2.64	328	59	0	1RRV	3.1
Cx. (Culex) quinquefasciatus	**36**	0.28	**34**	**20**	**0**		
Female	36	0.28	34	20	0		
***Cx*. species (unidentified) - new or difficult to ID species**	**2**	0.02	**2**	**2**	**0**		
Male	2	0.02	2	2	0		
Unidentifiable *Aedes* sp. (too damaged/features missing)	**42**	0.33	**42**	**8**	**0**		
Female	42	0.33	42	8	0		
Unidentifiable *Culex* sp. (too damaged/features missing)	**2**	0.02	**1**	**1**	**0**		
Female	2	0.02	1	1	0		
Grand Total	**12674**	**100**	**11228**	**972**	**8**	**16RRV**	**1.4**

Table 7: Details of mosquitoes collected and processed for virus isolation, Capel, southwest of Western Australia, 1 July 2016 to 30 June 2017.

Species	Total	%	Processed	Pool count	Pinned	Virus	MIR
Ae. (Finlaya) alboannulatus	**324**	**1.89**	**246**	**48**	**0**		
Bloodfed	3	0.02	0	0	0		
Female	320	1.87	245	47	0		
Male	1	0.01	1	1	0		
Ae. (Finlaya) mallochi	**2**	**0.01**	**1**	**1**	**1**		
Female	2	0.01	1	1	1		
Ae. (Finlaya) notoscriptus	**107**	**0.62**	**74**	**22**	**0**		
Female	107	0.62	74	22	0	1RRV	13.7
Ae. (Macleaya) tremulus	**1**	**0.01**	**0**	**0**	**1**		
Female	1	0.01	0	0	1		
Ae. (Ochlerotatus) camptorhynchus	**14678**	**85.71**	**7754**	**410**	**0**		
Bloodfed	89	0.52	0	0	0		
Female	14587	85.17	7753	409	0	4RRV	0.5
Male	2	0.01	1	1	0		
Ae. (Ochlerotatus) clelandi	**12**	**0.07**	**7**	**5**	**0**		
Female	12	0.07	7	5	0	1RRV	147.3
Ae. (Ochlerotatus) hesperonotius	**8**	**0.05**	**8**	**6**	**0**		
Female	8	0.05	8	6	0		
Ae. (Ochlerotatus) ratcliffei	**513**	**3.00**	**190**	**14**	**0**		
Bloodfed	3	0.02	0	0	0		
Female	510	2.98	190	14	0		
Ae. (Ochlerotatus) turneri	**7**	**0.04**	**1**	**1**	**0**		
Female	7	0.04	1	1	0		
An. (Anopheles) atratipes	**1**	**0.01**	**1**	**1**	**0**		
Female	1	0.01	1	1	0		
An. (Cellia) annulipes s.l.	**632**	**3.69**	**598**	**54**	**0**		
Bloodfed	1	0.01	0	0	0		
Female	628	3.67	595	51	0		
Male	3	0.02	3	3	0		
Cq. (Coquillettidia) species near linealis	**6**	**0.04**	**6**	**3**	**0**		
Female	6	0.04	6	3	0		
Cs. (Culicella) atra	**8**	**0.05**	**7**	**6**	**0**		
Female	7	0.04	6	5	0		
Male	1	0.01	1	1	0		
Cx. (Culex) annulirostris	**103**	**0.60**	**101**	**17**	**0**		
Female	103	0.60	101	17	0		
Cx. (Culex) australicus	**158**	**0.92**	**120**	**25**	**0**		
Female	158	0.92	120	25	0		
Cx. (Culex) globocoxitus	**545**	**3.18**	**520**	**51**	**0**		
Female	545	3.18	520	51	0		
Cx. (Culex) quinquefasciatus	**2**	**0.01**	**2**	**2**	**0**		
Female	2	0.01	2	2	0		
***Cx*. species (unidentified) - new or difficult to ID species**	**5**	**0.03**	**3**	**3**	**0**		
Male	5	0.03	3	3	0	1RRV	333.3
Unidentifiable *Aedes* sp. (too damaged/features missing)	**1**	**0.01**	**1**	**1**	**0**		
Female	1	0.01	1	1	0		
Unidentifiable *Culex* sp. (too damaged/features missing)	**13**	**0.08**	**12**	**5**	**0**		
Female	13	0.08	12	5	0		
Grand Total	**17126**	**100**	**9652**	**675**	**2**	**7RRV**	**0.7**

Table 8: Details of mosquitoes collected and processed for virus isolation, Busselton wetlands sites, southwest of Western Australia, 1 July 2016 to 30 June 2017.

Species	Total	%	Processed	Pool count	Pinned	Virus	MIR
Ae. (Finlaya) alboannulatus	**415**	**7.54**	**414**	**48**	**0**		
Bloodfed	1	0.00	0	0	0		
Female	414	7.54	414	48	0	1RRV	2.4
Ae. (Finlaya) notoscriptus	**30**	**0.44**	**24**	**14**	**0**		
Female	30	0.44	24	14	0		
Ae. (Ochlerotatus) camptorhynchus	**2442**	**43.36**	**2380**	**148**	**0**		
Bloodfed	58	0.00	0	0	0		
Female	2384	43.36	2380	148	0	10RRV	4.3
Ae. (Ochlerotatus) clelandi	**473**	**8.47**	**465**	**36**	**4**		
Bloodfed	4	0.00	0	0	0		
Female	467	8.44	463	35	4		
Male	2	0.04	2	1	0		
***Ae. (Ochlerotatus) clelandi* with banded legs**	**4**	**0.00**	**0**	**0**	**4**		
Female	4	0.00	0	0	4		
Ae. (Ochlerotatus) hesperonotius	**515**	**9.33**	**512**	**35**	**0**		
Bloodfed	3	0.00	0	0	0		
Female	512	9.33	512	35	0	1RRV	2.0
Ae. (Ochlerotatus) ratcliffei	**15**	**0.27**	**15**	**6**	**0**		
Female	15	0.27	15	6	0		
Ae. (Ochlerotatus) turneri	**19**	**0.27**	**15**	**6**	**4**		
Female	19	0.27	15	6	4		
Ae. (Ochlerotatus) vigilax	**51**	**0.93**	**51**	**8**	**0**		
Female	51	0.93	51	8	0		
***Ae*. species (unidentified) - new or difficult to ID species**	**2**	**0.02**	**1**	**1**	**1**		
Male	2	0.02	1	1	1		
An. (Anopheles) atratipes	**1**	**0.02**	**1**	**1**	**0**		
Female	1	0.02	1	1	0		
An. (Cellia) annulipes s.l.	**256**	**4.66**	**256**	**34**	**0**		
Female	255	4.65	255	33	0		
Male	1	0.02	1	1	0		
***An*. species (unidentified) - new or difficult to ID species**	**2**	**0.04**	**2**	**2**	**0**		
Male	2	0.04	2	2	0		
Cq. (Coquillettidia)* species near *linealis	**13**	**0.24**	**13**	**3**	**0**		
Female	13	0.24	13	3	0		
Cs. (Culicella) atra	**22**	**0.40**	**22**	**13**	**0**		
Female	20	0.36	20	11	0		
Male	2	0.04	2	2	0		
Cx. (Culex) annulirostris	**17**	**0.31**	**17**	**10**	**0**		
Female	17	0.31	17	10	0		
Cx. (Culex) australicus	**163**	**2.95**	**162**	**32**	**0**		
Bloodfed	1	0.00	0	0	0		
Female	162	2.95	162	32	0		
Cx. (Culex) globocoxitus	**935**	**17.02**	**934**	**71**	**0**		
Bloodfed	1	0.00	0	0	0		
Female	934	17.02	934	71	0		
Cx. (Culex) quinquefasciatus	**6**	**0.09**	**5**	**3**	**0**		
Female	6	0.09	5	3	0		
Cx. (Neoculex) latus	**2**	**0.04**	**2**	**2**	**0**		
Female	2	0.04	2	2	0		
***Cx*. species (unidentified) - new or difficult to ID species**	**80**	**1.46**	**80**	**14**	**0**		
Male	80	1.46	80	14	0		
Unidentifiable (too damaged/features missing)	**2**	**0.04**	**2**	**2**	**0**		
Male	2	0.04	2	2	0		
Unidentifiable *Aedes* sp. (too damaged/features missing)	**14**	**0.26**	**14**	**7**	**0**		
Female	14	0.26	14	7	0		
Unidentifiable *Culex* sp. (too damaged/features missing)	**10**	**0.18**	**10**	**7**	**0**		
Female	7	0.13	7	5	0		
Male	3	0.05	3	2	0		
Grand Total	**5489**	**100**	**5397**	**503**	**13**	**12RRV**	**2.2**

Table 9: Details of virus detections in mosquitoes collected in Southwest of WA, 1 July 2016 to 30 June 2017.

Locality	Date of collection	Trap location	Species	Virus	Number of positive pools
Peel					
	08.09.16	Lake Goegrup	*Aedes camptorhynchus*	RRV	1
	17.10.16	Riverview	*Aedes camptorhynchus*	RRV	1
	31.10.16	Lake Goegrup	*Aedes camptorhynchus*	BFV	1
			Aedes camptorhynchus	RRV	1
Leschenault					
	31.10.16	Washington Avenue	*Ae. alboannulatus*	RRV	1
			Ae. camptorhynchus	RRV	2
			Ae. hesperonotius	RRV	4
	15.11.16	Crimp Crescent	*Ae. alboannulatus*	RRV	1
			Ae. camptorhynchus	RRV	4
			Coquillettidia species near *linealis*	RRV	1
		Point Douro	*Cx. globocoxitus*	RRV	1
		Pratt Road swamp	*Ae. camptorhynchus*	RRV	2
Capel					
	31.10.16	Woods Road	*Ae. camptorhynchus*	RRV	4
			Ae. clelandi	RRV	1
			Ae. notoscriptus	RRV	1
		Stirling and Higgins Roads intersection	*Culex* male	RRV	1
Busselton					
	15.11.16	Busselton radio tower	*Ae. camptorhynchus*	RRV	2
			Ae. hesperonotius	RRV	3
	28.11.16	Quindalup	*Ae. alboannulatus*	RRV	1
			Ae. camptorhynchus	RRV	8

Northern Mosquito Surveillance

During 2016/17, mosquito collection were conducted in the Kimberley and Pilbara regions of WA between 15th March to 13th April 2017.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:

- Halls Creek
- Kununurra
- Parry's Creek
- Wyndham
- Billiluna
- Fitzroy Crossing
- Derby
- Broome
- Willie Creek
- Roebuck Plains
- Pt Hedland
- Tom Price
- Newman
- Meekatharra

The mosquitoes were collected in dry ice (carbon dioxide) baited EVS (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.

The 2016/17 mosquito collections are still being processed and results will be reported in the 2017/18 Annual Report.

Mosquito collections and arbovirus isolations from the Kimberley region, 2015/16

During 2015/16, mosquito collection was conducted in the Kimberley regions of WA between 15th March and 16th April 2016.

A total of 123 adult mosquito traps were set in the East Kimberley region at Halls Creek, Billiluna, Wyndham (including Parry's Creek) and Kununurra (Table 10). Mosquito abundance was moderate. Across the region *Culex annulirostris* was the most abundant species followed by *Ae normanensis*. Around Wyndham, *Ae. vigilax* was the most abundant (Table 10). Arbovirus isolates included one MVEV at Kununurra, one WNV_{KUN} at Billiluna, each from *Cx. annulirostris*; one alphavirus at Kununurra from *Cx. pullus*; and 16 non-alpha/non-flavivirus from a variety East Kimberley locations and mosquito species (Table 11).

Other notable mosquito species collected in the East Kimberley region included *Hodgesia* E.N.M. species number 157 and *Uranotaenia* sp. at Kununurra.

In the West Kimberley region a total of 78 adult mosquito traps were set at Fitzroy Crossing, Derby, Broome (including Willie Creek) and Lombadina. Mosquito abundance was very low throughout the West Kimberley due to a dry wet season. The most abundant species collected was *Cx. sitiens* around the tidal flats at Willie Creek (Table 11). No arboviruses were isolated from mosquitoes collected in the West Kimberley region.

Table 10: Mosquito collection summary and number of traps set in the Kimberley region in March - April 2016.

Locality	Total no. of mosquitoes	Total no. of traps set	No. of successful traps
East Kimberley			
East Kimberley	**810**		
Halls Creek	810	15	15
North east Kimberley	**7333**		
Kununurra	3906	67	67
Wyndham	3427	30	30
South east Kimberley	**3519**		
Billiluna	3519	12	12
West Kimberley			
Fitzroy River floodplain	**300**		
Fitzroy River floodplain	169	15	14
Geikie Gorge	131	9	9
Lower Fitzroy River floodplain	**277**		
Derby	196	15	15
Mowanjum community	14	4	4
Willare	67	4	4
West Kimberley	**4740**		
Broome	783	22	22
Coconut Wells	195	3	3
Willie Creek	3733	4	4
Roebuck Plain	24	11	10
Lombadina	5	1	1
Total	**16979**	**212**	**211**

Table 11: Mosquito collections from the Kimberley region in March - April 2016.

Species	Total	%	Processed	Pool Count	Pinned
Ad. (Aedeomyia) catasticta	**181**	**1.07**	**180**	**42**	**0**
Female	180	1.06	179	41	0
Male	1	0.01	1	1	0
Ae. (Chaetocruiomyia) elchoensis	**2**	**0.01**	**0**	**0**	**2**
Female	2	0.01	0	0	2
Ae. (Finlaya) britteni	**3**	**0.02**	**0**	**0**	**1**
Female	2	0.01	0	0	1
Male	1	0.01	0	0	0
Ae. (Finlaya) kochi group	**1**	**0.01**	**0**	**0**	**1**
Female	1	0.01	0	0	1
***Ae. (Finlaya)* new undescribed species**	**5**	**0.03**	**2**	**0**	**3**
Female	5	0.03	2	0	3
Ae. (Finlaya) notoscriptus	**275**	**1.62**	**275**	**51**	**0**
Female	274	1.61	274	50	0
Male	1	0.01	1	1	0
***Ae. (Macleaya)* species**	**1058**	**6.23**	**1038**	**180**	**0**
Bloodfed	1	0.01	0	0	0
Female	514	3.03	504	89	0
Male	543	3.20	534	91	0
Ae. (Macleaya) tremulus	**326**	**1.92**	**325**	**34**	**0**
Bloodfed	1	0.01	0	0	0
Female	143	0.84	143	27	0
Male	182	1.07	182	7	0
Ae. (Mucidus) alternans	**39**	**0.23**	**39**	**25**	**0**
Female	39	0.23	39	25	0
Ae. (Neomellanoconion) lineatopennis	**173**	**1.02**	**172**	**28**	**0**
Female	173	1.02	172	28	0
***Ae. (Ochlerotatus)* E.N. Marks' species No. 159**	**1**	**0.01**	**0**	**0**	**1**
Female	1	0.01	0	0	1
Ae. (Ochlerotatus) normanensis	**1826**	**10.75**	**1725**	**144**	**0**
Bloodfed	101	0.59	0	0	0
Female	1722	10.14	1722	141	0
Male	3	0.02	3	3	0

Species	Total	%	Processed	Pool Count	Pinned
Ae. (Ochlerotatus) pseudonormanensis	**21**	**0.12**	**18**	**7**	**0**
Bloodfed	1	0.01	0	0	0
Female	20	0.12	18	7	0
Ae. (Ochlerotatus) vigilax	**1714**	**10.09**	**1710**	**96**	**1**
Bloodfed	2	0.01	0	0	0
Female	1712	10.08	1710	96	1
Ae. (Ochlerotatus) vittiger	**74**	**0.44**	**68**	**5**	**0**
Bloodfed	5	0.03	0	0	0
Female	69	0.41	68	5	0
Ae. (Pseudoskusea) bancroftianus	**19**	**0.11**	**19**	**8**	**0**
Female	19	0.11	19	8	0
Ae. (Stegomyia) katherinensis	**1**	**0.01**	**0**	**0**	**0**
Female	1	0.01	0	0	0
Ae. (Subgenus Nov.) daliensis	**66**	**0.39**	**25**	**4**	**0**
Female	64	0.38	24	3	0
Male	2	0.01	1	1	0
***Ae.* species (unidentified) - new or difficult to ID species**	**5**	**0.03**	**5**	**4**	**0**
Male	5	0.03	5	4	0
An. (Anopheles) bancroftii	**170**	**1.00**	**170**	**27**	**0**
Female	170	1.00	170	27	0
An. (Cellia) amictus	**113**	**0.67**	**113**	**23**	**0**
Female	113	0.67	113	23	0
An. (Cellia) annulipes s.l.	**555**	**3.27**	**535**	**79**	**1**
Bloodfed	18	0.11	0	0	0
Female	536	3.16	534	78	1
Male	1	0.01	1	1	0
An. (Cellia) meraukensis	**20**	**0.12**	**20**	**13**	**0**
Female	20	0.12	20	13	0
***An.* species (unidentified) - new or difficult to ID species**	**4**	**0.02**	**4**	**4**	**0**
Male	4	0.02	4	4	0
Cq. (Coquillettidia) xanthogaster	**687**	**4.05**	**685**	**68**	**0**
Bloodfed	2	0.01	0	0	0
Female	657	3.87	657	57	0
Male	28	0.16	28	11	0
Cx. (Culex) annulirostris	**4139**	**24.38**	**4072**	**270**	**0**
Bloodfed	60	0.35	0	1	0
Female	4079	24.02	4072	269	0
Cx. (Culex) bitaeniorhynchus	**40**	**0.24**	**37**	**11**	**2**
Bloodfed	1	0.01	0	0	0
Female	39	0.23	37	11	2
Cx. (Culex) crinicauda	**7**	**0.04**	**7**	**4**	**0**
Female	7	0.04	7	4	0
Cx. (Culex) palpalis	**8**	**0.05**	**8**	**3**	**0**
Female	8	0.05	8	3	0
Cx. (Culex) quinquefasciatus	**72**	**0.42**	**72**	**28**	**0**
Female	72	0.42	72	28	0
Cx. (Culex) sitiens	**3851**	**22.68**	**2250**	**107**	**0**
Bloodfed	4	0.02	0	0	0
Female	3844	22.64	2248	105	0
Male	3	0.02	2	2	0
Cx. (Culex) squamosus	**12**	**0.07**	**8**	**5**	**0**
Female	12	0.07	8	5	0
Cx. (Culex) starckeae	**6**	**0.04**	**4**	**3**	**1**
Female	6	0.04	4	3	1
Cx. (Culiciomyia) pullus	**69**	**0.41**	**69**	**31**	**0**
Female	69	0.41	69	31	0
Cx. (Lophoceraomyia) cubiculi	**2**	**0.01**	**1**	**1**	**0**
Female	2	0.01	1	1	0
Cx. (Lophoceraomyia) cylindricus	**9**	**0.05**	**9**	**5**	**0**
Female	9	0.05	9	5	0
***Cx.* (*Lophoceraomyia*) E.N.Marks' species No. 167**	**102**	**0.60**	**102**	**14**	**0**
Female	102	0.60	102	14	0

Species	Total	%	Processed	Pool Count	Pinned
Cx. (Lophoceraomyia) fraudatrix	**14**	**0.08**	**10**	**5**	**4**
Female	14	0.08	10	5	4
Cx. (Lophoceraomyia) hilli	**2**	**0.01**	**2**	**1**	**0**
Female	2	0.01	2	1	0
Cx. (*Lophoceraomyia*) species	**6**	**0.04**	**6**	**5**	**0**
Female	6	0.04	6	5	0
***Cx*. species (unidentified) - new or difficult to ID species**	**15**	**0.09**	**15**	**10**	**0**
Male	15	0.09	15	10	0
***Hodgesia* E. N. Marks' species No. 157**	**16**	**0.09**	**15**	**1**	**0**
Female	16	0.09	15	1	0
Ma. (Mansonioides) uniformis	**774**	**4.56**	**773**	**63**	**0**
Bloodfed	1	0.01	0	0	0
Female	772	4.55	772	62	0
Male	1	0.01	1	1	0
Tripteroides (Polylepidomyia) punctolateralis	**30**	**0.18**	**29**	**14**	**1**
Female	30	0.18	29	14	1
Unidentifiable (too damaged/features missing)	**6**	**0.04**	**6**	**1**	**0**
Female	6	0.04	6	1	0
Unidentifiable *Aedes* sp. (too damaged/features missing)	**60**	**0.35**	**60**	**16**	**0**
Female	60	0.35	60	16	0
Unidentifiable *Anopheles* sp. (too damaged/features missing)	**38**	**0.22**	**38**	**12**	**0**
Female	38	0.22	38	12	0
Unidentifiable *Culex* sp. (too damaged/features missing)	**307**	**1.81**	**304**	**58**	**1**
Bloodfed	1	0.01	0	0	0
Female	306	1.80	304	58	1
Unidentified dipteran	**1**	**0.01**	**1**	**1**	**0**
Female	1	0.01	1	1	0
Ur. (Uranotaenia) albescens	**3**	**0.02**	**0**	**0**	**3**
Female	1	0.01	0	0	1
Male	2	0.01	0	0	2
Ur. (Uranotaenia) nivipes	**3**	**0.02**	**1**	**1**	**2**
Female	3	0.02	1	1	2
Ve. (Verrallina) funerea	**11**	**0.06**	**9**	**2**	**0**
Female	11	0.06	9	2	0
Ve. (Verrallina) reesi	**37**	**0.22**	**35**	**11**	**0**
Female	37	0.22	35	11	0
Grand Total	**16979**	**100**	**15071**	**1525**	**24**

Table 12: Details of virus isolations from mosquitoes collected in the Kimberley region in March - April 2016.

Date	TrapSite	Species	Viruses
19-Mar-16	Halls Creek sewage ponds, 4.1km along Duncan Highway, set in trees 100m from SE corner of sewage ponds	*Ae. (Mucidus) alternans*	nA/F
21-Mar-16	Sturt Creek concrete xing, Billiluna (NW) side, 80m N along west bank of creek	*Cx. (Culex) annulirostris*	nA/F
21-Mar-16	Myarra Pool, Sturt Creek	*An. (Cellia) annulipes* s.l.	nA/F
21-Mar-16	Sturt Creek concrete xing, Billiluna (NW) side, 80m N along west bank of creek	*Cx. (Culex) annulirostris*	WNV_{KUN}
24-Mar-16	Ivanhoe Crossing, set on upstream / Kununurra side of crossing	*Cx. (Culiciomyia) pullus*	ALFV
24-Mar-16	Dumas' lookout, Kununurra	*Cx. (Culex) annulirostris*	MVEV
25-Mar-16	14.2km from gravel commencement of Weaber Plains Rd, drain crossing, Kununurra	*An. (Cellia) annulipes* s.l.	nA/F
27-Mar-16	Set on right hand side of Victoria highway at Emu Creek, Kununurra	*Cx. (Culex) bitaeniorhynchus*	nA/F
27-Mar-16	Buddha head swamp off Crossing Falls Road, Kununurra	*An. (Cellia) annulipes* s.l.	nA/F
27-Mar-16	Dryandra Rd termination, KNX, adj. Little Lily creek line, Kununurra	*Cq. (Coquillettidia) xanthogaster*	nA/F
27-Mar-16	Dryandra Rd termination, KNX, adj. Little Lily creek line, Kununurra	Unidentifiable *Culex* sp. (too damaged/features missing)	nA/F
28-Mar-16	KNX sentinel chicken flock. Lot 137 Whimbrel Way, Rob Floyds house, Kununurra	*Ae. (Ochlerotatus) normanensis*	nA/F
28-Mar-16	Weaber Plains Road, 3.1km from jnt with Leichardt Street, Kununurra	*Ae. (Macleaya) species*	nA/F
28-Mar-16	Weaber Plains Road, 3.1km from jnt with Leichardt Street, Kununurra	*Ad. (Aedeomyia) catasticta*	nA/F
28-Mar-16	Weaber Plains Road, 5.1km from junction with Leichardt Street, Kununurra	*Cx. (Culex) annulirostris*	nA/F
28-Mar-16	Weaber Plains Road, 5.1km from junction with Leichardt Street, Kununurra	*Ae. (Ochlerotatus) normanensis*	nA/F
28-Mar-16	Weaber Plains Road, 3.1km from jnt with Leichardt Street, Kununurra	*Ae. (Ochlerotatus) normanensis*	nA/F
29-Mar-16	Parry's Creek crossing, Parry's Creek Road, in mangrove on NW cnr of crossing	Unidentifiable *Anopheles* sp. (too damaged/features missing)	nA/F
29-Mar-16	Marlgu nature reserve, Parry's Lagoons, set at billabong	*Cx. (Culex) annulirostris*	nA/F

ALFV –Alfuy virus, nA/F-Not an alpha or flavivirus but still to be identified, WNV_{KUN} - West Nile virus Kunjin strain, MVEV - Murray Valley encephalitis virus

MVE virus and WNV_{KUN} Surveillance

In WA, the DoH monitors flaviviruses via a sentinel chicken program and 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 Flavivirus 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 2016/17, 24 sentinel chicken flocks were located in major towns and communities in the Kimberley, Pilbara, Gascoyne, Midwest, Wheatbelt and regions of WA (Figure 25).

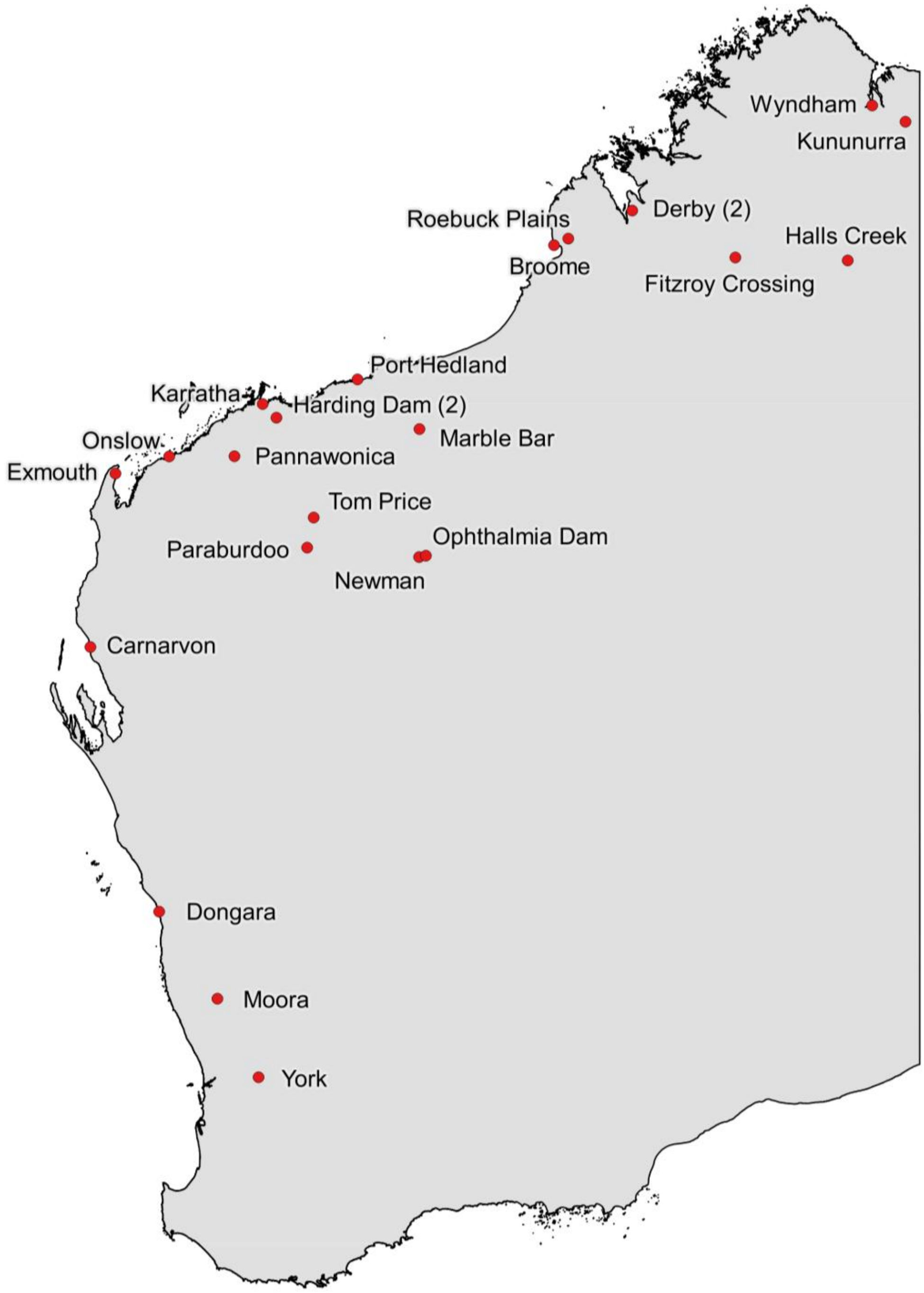


Figure 25: Locations of the sentinel chicken flocks in WA in 2016/17.

The level of flavivirus activity in sentinel chickens in northern WA in 2016/17 increased compared to previous years, with the Kimberley and Pilbara regions experiencing the most activity (Table 13). Seroconversions were detected in 128 of the 3807 samples tested (3.36%).

Table 13: Number of sentinel chickens that developed antibody to flaviviruses during 2016/17.

Site	Month	No. of chickens/Antibody				
		M	K	MK	F	Total
KIMBERLEY						
Wyndham	March	2	3			5
	April	1	1		1	3
	May		1		1	2
Kununurra	March		3			3
	April	1	2		1	4
Halls Creek	May		2			2
	June				1	1
Fitzroy Crossing	March	1				1
	April	1	2			3
	May		2			2
	June		1			1
Derby site1	May	1				1
Derby site 2	May	2	3			5
	June		3			3
Broome	May	4	2	1		7
Roebuck Plains Station	March		1	1		2
	April	2	1		2+1*	6
PILBARA						
Port Hedland	April	1	1			2
	May	1	1			2
	June	2			1	3
Karratha	March	1	3		1	5
	April		1		2	3
	May	1	1			2
Harding Dam Site 1	March	1	1			2
	April		1			1
Harding Dam Site 2	April	4			1	5
	May		1			1
Marble bar	May	2	7			9
	June				1	1
Pannawonica	March	1	1			2
	April		5	1	1	7
Paraburdoo	March	1	2			3
	April	3	3			6
Tom Price	February		1			1
	March	3				3
	April	3	3			6
Ophthalmia Dam	March	4	3	1		8
	April	2				2
Onslow	March	1				1
	June		1			1
MIDWEST/WHEATBELT						
Moora	Dec-May		1			1

* re-bleed could not be obtained; called confirmed flavi+ (epidemiology and strong positive reaction in serological tests)

M = MVE, K = Kunjin, MK = MVE/Kunjin, F = Flavivirus

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.

The Department of Health spent $582,529.61 (including contractor retainer cost) in the provision of aerial larviciding treatments through procurement of helicopter services in the Southwest region. A total of 39 aerial larvicide treatments covering over 4,000 hectares were undertaken during the 2016/17 financial year (Table 14).

Table 14: Number of aerial treatments and area treated by region during 2016/17.

Regions	Treatments	Area treated (ha)
Peel	25	2511.3
Leschenault	7	191.8
Geographe	7	1315.9
Total	**39**	**4019.0**

The most commonly used larvicides were granulated forms of S-methoprene and *Bacillus thuringiensis israelensis* (Bti).This is the fourth 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 two importations of exotic mosquitoes at the Perth International Airport during the 2016/2017 financial year. The DoH confirmed the identifications as *Aedes aegypti* collected in DAWR mosquito monitoring traps. The DoH's Medical Entomology team conducted extensive mosquito ground surveillance around the airport freight depot at which the detections were made. In addition, Medical Entomology provided technical advice and supervision of mosquito control treatments and ongoing monitoring.

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 15 active CLAGs in WA during 2016/17 (Fig. 27):

- 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);
- Halls Creek (Shire of Halls Creek)
- Leschenault (City of Bunbury and Shires of Dardanup and Harvey);
- Karratha (City of Karratha);
- Peel (Cities of Mandurah and Rockingham and Shires of Murray and Waroona);
- Port Hedland (Town of Port Hedland);
- South Metropolitan (City of Cockburn and City of Kwinana);
- 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).

Esperance and South Coast (Albany) CLAGs were formed during 2016/17 but did not apply for funding in this year, therefore are not technically active until the 2017/18 year.

Department of Health provided funding to the amount of $237,880.86 to the CLAGs to assist with mosquito control in 2016/17. The amount each CLAG received was dependent on their unique requirements.

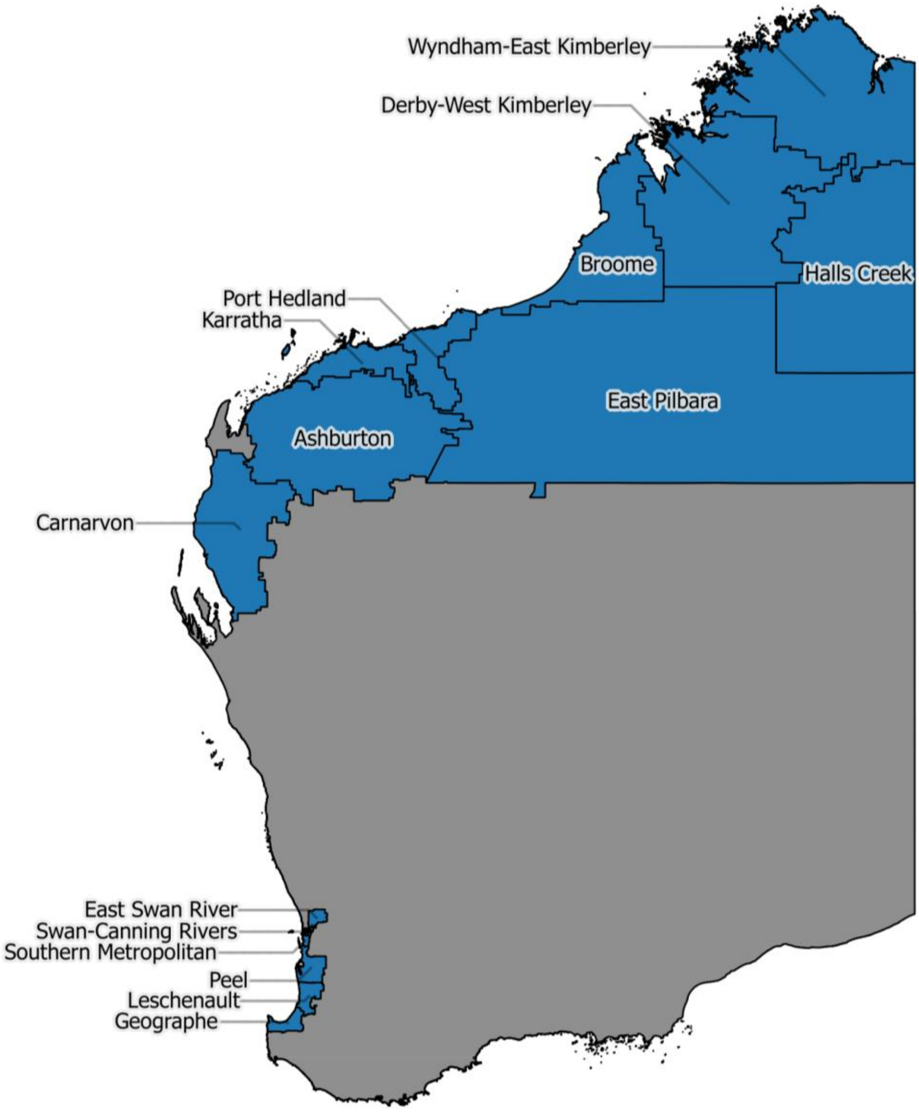


Figure 26: WA map showing CLAG (Contiguous Local Authority Group) boundaries of local governments participating in the CLAG Funding Scheme during 2016/17.

Funding Initiative for Mosquito Management in Western Australia (FIMMWA)

FIMMWA was established in 2013 following a directive by the Minister for Health to provide an additional $1 million a year for four years (totaling $4 million). The Medical Entomology team, within the Department's Environmental Health Directorate, managed all aspects of the initiative over its four year duration (2013/14 – 2016/17). Annual funding was split between local government (LG) mosquito management programs ($300,000 per year), progressing key capacity building projects ($500,000 per year) and establishing a competitive research grant scheme ($200,000 per year) – each of which will be discussed separately below.

FIMMWA funding ceased on 30 June 2017. A significant project from the 2016/17 financial year has been to evaluate the FIMMWA initiative. In reflecting on the outcomes of FIMMWA, it is clear that this unique opportunity has built corporate knowledge and expertise within both State and LG authorities to deliver risk-based, effective mosquito management programs in those regions of WA at greatest risk from mosquito-borne diseases. A survey of LG representatives involved in FIMMWA was recently undertaken to evaluate the program and the significance of its outcomes. This allowed the DoH to identify key funding initiatives that have been incorporated into mosquito management programs across WA and that warrant continued support by the Department after FIMMWA ends, subject to adequate resourcing. These initiatives include the Atlas of Environmental Health, *Fight the Bite*, further assessment of the value of winter aerial treatments and expansion of items eligible for funding under the existing *Standard CLAG Funding* scheme.

As a fitting salute to FIMMWA, the initiative was recently shortlisted as a finalist in the Institute of Public Administration Australia (IPAA) WA Achievement Awards. The ME team worked closely with LG over the life of the initiative, ensuring its outcomes improved both State and LG capacity to undertake mosquito management throughout WA. As such, FIMMWA was nominated in the '*Best Practice in Collaboration Across Government Agencies'* category. The awards ceremony was held on 30th June, 2017, where FIMMWA did not win the category.

The full FIMMWA evaluation is documented in a dedicated report elsewhere. The remainder of this section will discuss FIMMWA funding and activities related to the 2016/17 financial year only.

Additional Funding to Local Government

A total of $284,918.67 was awarded in 2016/17 through FIMMWA to LGs to improve mosquito control and build capacity for mosquito management within their programs. Funding was available via a competitive application process to all LGs within CLAGs and those with a Memorandum of Understanding (MoU) in place with DoH, indicating their intention to form a CLAG.

Applications were assessed by the expanded Mosquito Control Advisory Committee (MCAC), consisting of representatives from DoH, the Department of Parks and Wildlife (DPaW), the Department of Planning, as well as a regional and a metropolitan LG representative. The committee considered several criteria in their decision to approve requested items including the cost-effectiveness of the request, the likelihood that it would have an ongoing contribution to the mosquito program and the overall benefit of the request to public health.

Eligible LGs were able to apply for resources/assets through FIMMWA that are not typically available through *Standard CLAG Funding* or where funding is limited. As such, funding for the purchase of chemicals was not permitted through this initiative. Commonly requested items include, but were not limited to:

- equipment for breeding site assessment, mosquito identification and mosquito management;
- external expertise/consultants to evaluate existing mosquito management programs;
- community education related resources;
- short term staffing contracts to assist in mosquito management over peak seasons;
- funding to attend conferences/training directly related to mosquito control; and
- IT equipment for field based documentation of mosquito populations.

FIMMWA Competitive Research Grants

The FIMMWA competitive research grant scheme aims to support (but is 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.

Eight applications (totaling $365,875.97) were received and reviewed by a panel comprising of the MCAC and the former WA Chief Scientist (Prof. Lyn Beazley) in 2016/17. The review panel supported four applications for funding which were subsequently endorsed by the Director of Environmental Health in July 2016, totaling $183,971.00 (Table 15).

Table 15: Successful research grants awarded in 2016/17.

Institution	Project	Grant
PathWest & WA Health	*Expanded assessment of sentinel passive traps (SMACKs) and FTA cards for arbovirus surveillance in WA & the NT*	**$52,511.00**
Dep't of Fisheries	*Mosquito larvae predation by fish from the Mandurah Peel-Harvey region*	**$47,775.00**
Murdoch University	*The role of the egg bank in causing mosquito booms during barometric tides*	**$33,685.00**
University of QLD	*Does a newly discovered insect-specific virus reduce the transmission of flavivirus pathogens in populations of Culex annulirostris mosquitoes?*	**$50,000.00**
	Total	**$183,971.00**

Capacity Building Projects

Through consultation with LG, a number of key Department-led projects were identified and progressed through FIMMWA to further improve the capacity of local and State authorities to undertake mosquito management. During the 2016/17 financial year, a total of $530,000.00 in FIMMWA funding was allocated to capacity building projects. A brief summary of these projects is provided below:

Communications campaign

Fight the Bite (*FTB*) is a communication campaign that partners with LG to actively raise awareness of mosquito-borne disease in WA. The campaign was launched during the 2015/16 season, and continued over the 2016/17 season. Despite a modest campaign budget ($45,000.00) and limited resourcing, media traction, stakeholder engagement and feedback from LG indicated that campaign uptake has been highly successful. Partnerships were established with over 40 LGs in WA, the WA branch of the Australian Medical Association (AMA), General Practices, key commercial outdoor cinema providers and a range of employers in the mining/resources sector, each keen to join the combined effort to reduce the impact of mosquito-borne disease in WA.

The two year pilot period for *FTB* came to an end during the 2016/17 financial year. A rigorous evaluation was undertaken, including a follow-up KAP (knowledge, attitudes, practices) phone survey (n=2,500) of individuals throughout WA to determine campaign reach and ascertain whether *FTB* exposure improved awareness and prevention practices. LG were also asked to complete an online survey to assess their view of the campaign. A preliminary analysis of the evaluation results has been undertaken. The evaluation KAP survey (May 2017) indicated *FTB* reached 10.8% of total sample population, exceeding the goal of 5%. This is particularly significant given the budget constraints and limited paid advertising involved. Campaign reach was greatest in the high risk, launch region of the Kimberley (26%), where LG were keenly engaged in *FTB*. Of those who recalled campaign-related material/media, awareness of mosquitoes and mosquito-borne disease improved in 44.3% of individuals. *FTB* reinforced correct preventative practices already undertaken in 63% of survey respondents and improved a further 28%. A small proportion (9.3%) did not change their behaviour.

All LG respondents who completed the online evaluation survey (*n*=36) felt the campaign had improved their communication efforts around mosquitoes. The vast majority (69%) felt *FTB* had significantly improved their efforts. Over 90% of survey participants expressed support for *FTB* to continue being supported into the future, further strengthening the collaborative partnership between DoH and LG. Numerous positive comments were submitted, serving as a testimonial to the campaign's success:

'Fight the bite! What an awesome addition to our local government area to support health and wellbeing'

'Fight the Bite is critical and should be embraced by all LG with mosquito issues... Resources are far more effective when we all incorporate a common message'

'Fight the Bite campaign is an excellent initiative to help engage the community and better communicate the message to members of the community to protect themselves and their families from mosquito borne disease'.

Over the course of the past 12 months significant time was spent, in partnership with LG, developing a range of innovative resources to target 'at risk' groups identified in the KAP survey. A selection of these resources is discussed below.

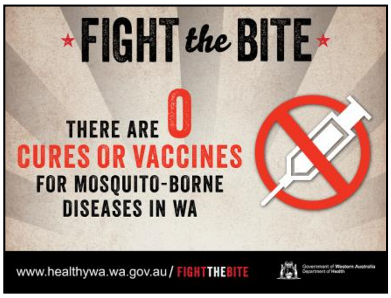
Fight the Bite Kits for Outdoor Events

A countertop display box, brochures, bulk repellent, posters and a screen ad were provided to LGs, community groups and commercial stakeholders to provide repellent free of charge to patrons of outdoor events (eg. concerts, movies). Key commercial stakeholders, Sunset Cinemas Broome, Somerville/PIAF and Community Cinemas (Burswood, Murdoch and Bassendean) are involved. Free screen advertising was provided to DoH at a number of locations to increase repellent uptake.

A similar kit (no repellent), with the addition of digital screen content and a *RRV Disease Management Guide,* was provided to medical practices. DoH is now partnering with 40+ GPs who actively promote *FTB* in the peak mosquito season.

Social Media

LG feedback indicated a demand for resources to support digital campaigns. In response, infographics accompanied by suggested posts were developed for use by LG. This is a channel the Department is looking to grow, as individuals (18-34yrs) are least aware of the risks associated with mosquitoes but are most likely to use social media.



FTB in Indigenous Communities:

A longer term goal to roll *FTB* out in indigenous communities was bought forward due to the success of the campaign within Perth and major regional towns. Discussions with Kimberley Population Health Unit indicated *FTB* was considered an ‘in town’ campaign and needed tailoring to suit indigenous communities. In response, a member of the ME team workshopped *FTB* at the Kimberley/Pilbara Aboriginal Environmental Health Forum in Broome with indigenous community representatives. This was highly productive, resulting in the development of resources that introduced *FTB* branding, yet retained cultural relevance.

With the FIMMWA funding initiative now ceased, the DoH will continue to play an overall role in managing FTB to retain campaign consistency and maximise stakeholder engagement.

Atlas of Environmental Health – Mosquito Monitoring App and Website

The Medical Entomology team continued to work with Gaia Resources in the expansion of an online mosquito management portal for the collection of mosquito and mosquito-borne disease data. The project aims to amalgamate data collected by local government, the Department of Health and PathWest Laboratory Medicine to better understand mosquito population dynamics and the incidents of mosquito-borne diseases. Additions to the mosquito monitoring website include the ability to produce larval reports, outlining the abundance and breakdown of mosquito instar stages across the State. In addition, the website now also contains the ability to record chemical stocks including the purchase and use of chemicals for mosquito control.

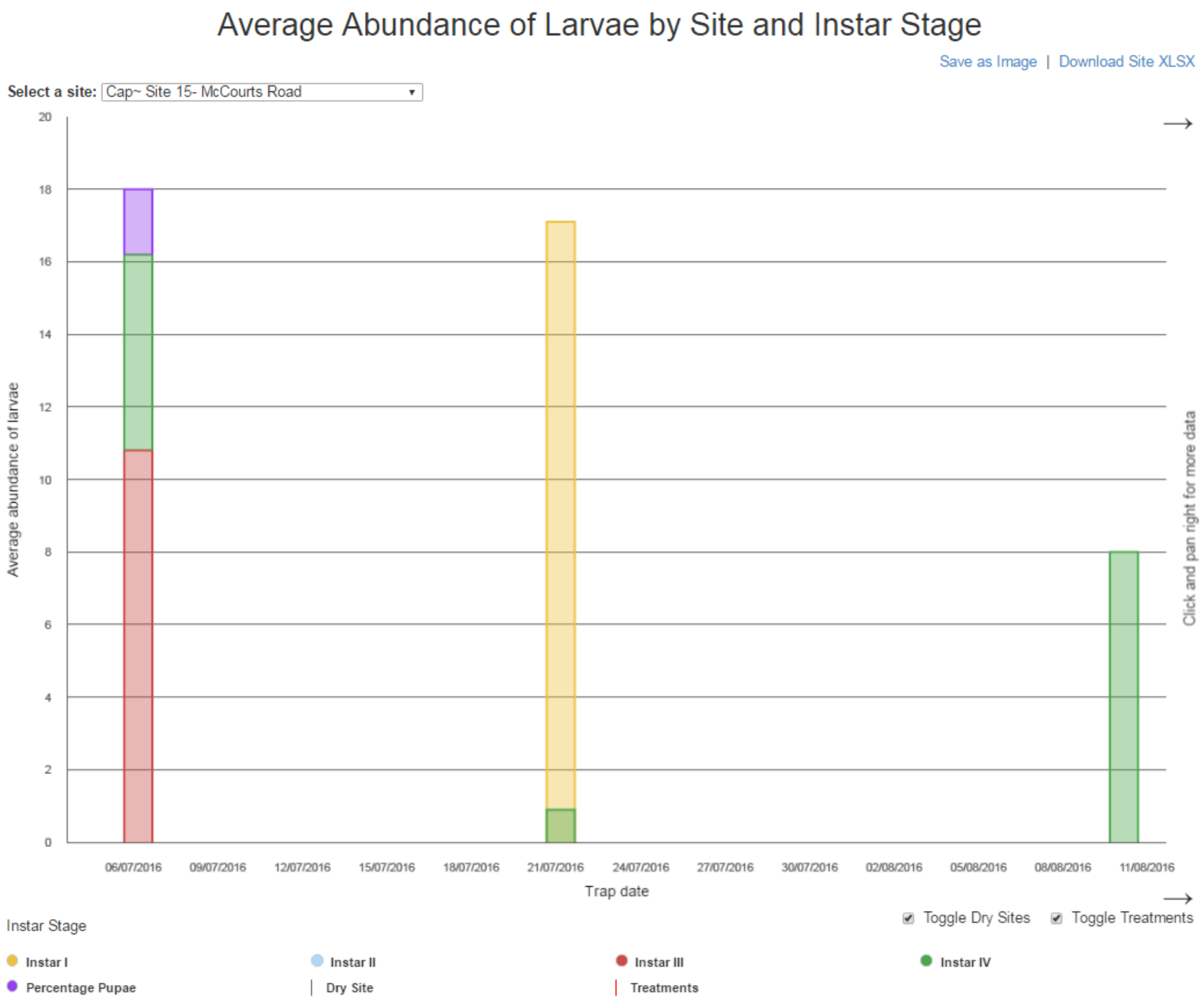


Figure 28A: Screen snapshot of the newly developed online Environmental Health Atlas – larval abundance reporting.

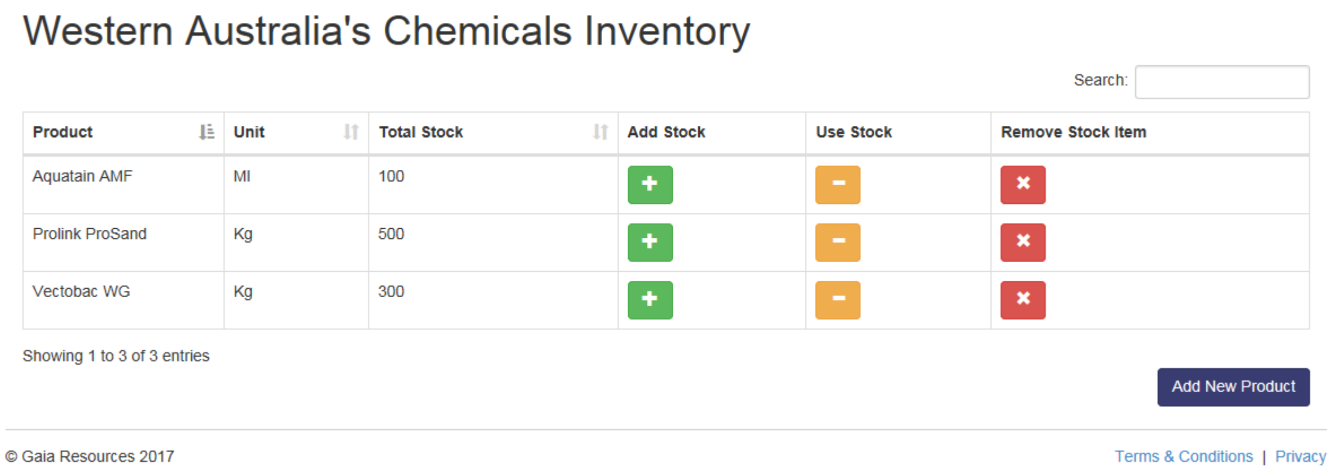


Figure 28B: Screen snapshot of the newly developed online Environmental Health Atlas – chemical inventory reporting.

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 and overseas 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 was 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.

Three further minor capacity building projects were also progressed:

- Tide Gauges
- Research Scholarships
- Emergency Management

DoH Training Workshops

Combined CLAG Forum 2017

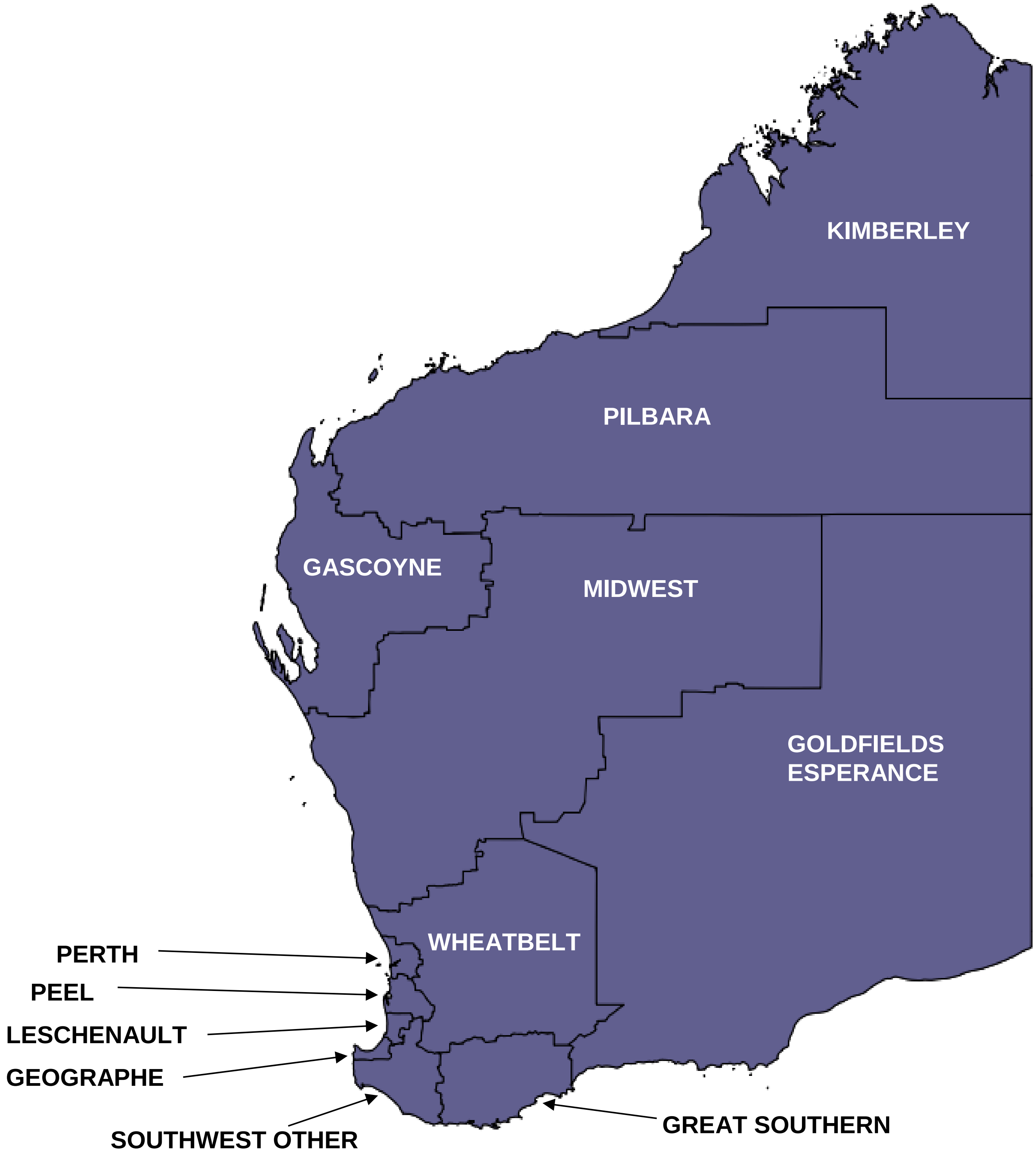
After the success of the previous five combined CLAG Forums and at the request of Local Governments to continue to hold an annual event, the Environmental Health Hazards Unit (Medical Entomology program) convened the sixth annual one day combined CLAG forum on 22 June 2017.

A total of 55 participants attended the event, including personnel from the Department of Health, Pathwest, MozTrack, Heliwest, Edith Cowan University, South Eastern Regional Centre for Urban Landcare and the following 21 Local Governments (LGs): Armadale, Bayswater, Belmont, Bunbury, Busselton, Canning, Capel, Cockburn, Dardanup, Harvey, Joondalup, Kwinana, Mandurah, Melville, Murray, Nedlands, Perth, Rockingham, South Perth, Swan, and Victoria Park.

Key themes discussed at this year's forum included a range of Funding Initiative for Mosquito Management in WA (FIMMWA) projects, an update on Mosquito management in WA and new surveillance techniques utilising unmanned aerial vehicles (UAV's or "drones") and other technology. Several LG Officers also presented on completed projects, research studies and mosquito management initiatives recently undertaken in their jurisdictions.

The level of attendance at this one day event is evidence that mosquito management remains a high priority for many LGs around Western Australia. It is hoped that the information presented at the forum will be used as a tool by participants to improve current mosquito management programs throughout the State. While officers from LGs in regional areas were unable to attend due to travel logistics, many have shown a great interest in the day. Consequently, presentations and notes from the Forum will be made available to those who were unable to attend.

Appendix 1: Map of WA State regions



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