Communicable Diseases Network Australia National Arbovirus and Malaria Advisory Committee annual report, 2005–06

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Abstract

This report describes the epidemiology of mosquito-borne disease in Australia for the mosquito-borne disease season 1 July 2005 to 30 June 2006, in which the second largest number of notifications since 1995–96 was reported. Ross River virus (RRV) infections (66%), Barmah Forest virus (BFV) infections (23%) and malaria (9%) were the most common mosquito-borne diseases reported in 2005–06. National RRV notifications were the fifth largest on record. The Northern Territory had the highest rate of RRV notifications and the peak notification rate (in January 2006) was the third highest since 2000. National BFV notification rates were the highest on record. The Northern Territory also reported the highest BFV notification rate this season, peaking in February–March 2006, which was the highest reported BFV notification rate on record. BFV notification rates were significantly higher in teenagers compared to previous seasons. There were 731 notifications of malaria in 2005–06 of which none was reported as locally acquired. This was the third highest reporting period for malaria notifications since 2000. In contrast to previous years in which *Plasmodium vivax* was the predominant species, *Plasmodium falciparum* was reported as the infecting species in 45 per cent of the malaria notifications and *Plasmodium vivax* for 42 per cent of cases. Young adults in the 20–24 year age group had the highest number of cases and children in the 5–9 year age group accounted for 22 per cent of notifications. There were two cases of Kunjin virus (KUNV) infection and one case of Murray Valley encephalitis virus (MVEV) infection reported in 2005–06, all from Western Australia. Sentinel chicken surveillance data for flaviviruses and sentinel pig surveillance data for Japanese encephalitis virus are reported. There were 200 notifications of dengue virus (DENV) infection in 2005–06, of which 46 per cent (n=92) was reported as having been acquired overseas. Dengue serotypes 2 and 3 were detected in two outbreaks of locally-acquired dengue in Queensland this season. *Commun Dis Intell* 2006;30:411–429.

Keywords: arbovirus; Barmah Forest virus, dengue, disease surveillance; epidemiology, flavivirus, Japanese encephalitis, Kunjin, malaria, mosquitoes, Murray Valley encephalitis virus, Ross River virus

Introduction

This report describes the epidemiology of nationally notifiable mosquito-borne disease in Australia for the season 1 July 2005 to 30 June 2006, which was the second largest season since 1995–96.

The eight notifiable mosquito-borne diseases under national surveillance include the alphaviruses (Barmah Forest virus and Ross River virus), the flaviviruses (dengue, Japanese encephalitis, Kunjin, Murray Valley encephalitis and flavivirus not elsewhere classified), and malaria.

Alphaviruses are ribonucleic acid (RNA) viruses which cause disease epidemics characterised by fever, rash and polyarthritis. In Australia, Barmah Forest virus (BFV) infection and Ross River virus (RRV) infection are the alphaviruses of major public health significance. There is a variety of mosquito vectors which facilitate the transmission of these viruses in diverse environments (freshwater habitats, coastal regions, salt marshes, floodwaters, established wetlands and urban areas).[1,2] At this time, the alphavirus chikungunya virus is not notifiable and has not become established in Australia despite its

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increased activity in southern Asia and the Indian Ocean over the past year, and its occasional diagnosis in returning travellers.

Flaviviruses are single-stranded RNA viruses, some of which are associated with epidemic encephalitis in various regions of the world. In Australia, the flaviviruses of public health importance are the dengue viruses (DENV) with frequent seasonal outbreaks,[3–6] Japanese encephalitis virus (JEV) with occasional outbreaks,[7–12] and sporadic cases of infection with Murray Valley encephalitis virus (MVEV) or Kunjin virus (KUNV).[13] The International Committee for Taxonomy of Viruses refers to Kunjin as a strain of West Nile virus (WNV)[14] and the Australian Kunjin strains are phylogenetically located in the WNV lineage 1, clade B.[15]

Malaria is caused by infection with a protozoan blood parasite from the genus *Plasmodium* that has been transmitted by a species of mosquito from the genus *Anopheles*. Malaria was eradicated from Australia in 1981 and Australia was certified malaria-free by the World Health Organization (WHO) in 1983,[16] but the region of northern Australia above 19°S latitude in particular, remains receptive to malaria transmission. Since 1981, malaria acquired in Australia has been rare, but there have been several documented reports of outbreaks[17,18] and sporadic introduced cases[19,20] in Queensland, malaria acquired in the Torres Strait,[21] and the artificial induction of malaria by blood transfusion.[22]

Methods

Eight nationally notifiable mosquito-borne diseases were analysed for the seasonal period 1 July 2005 to 30 June 2006. Historical data from 2000, and in some cases from 1991, are also shown for comparison. Data were extracted by diagnosis date from the National Notifiable Diseases Surveillance System (NNDSS) on 18 August 2006. Hospitalisation data where available, were extracted from the online National Hospital Morbidity database, Australian Institute of Health and Welfare.[23]

Epidemic curves by state or territory were produced for each of the eight diseases. Notifiable mosquito-borne disease activity is shown compared with a five-year mean for the same period by jurisdiction. The number of notifications and annual or annualised notification rates for locally acquired mosquito-borne disease were calculated using the December population estimates from the Australian Bureau of Statistics (ABS). Age- and sex-specific notification rates were calculated using age and sex population estimates for each jurisdiction.

The geographical distribution of selected diseases was mapped using ArcGIS (ESRI, Redlands, CA, USA). Maps were based on the postcode of residence of each notification aggregated to the appropriate Statistical Division, and rates were calculated using the number of notifications (numerator) divided by the estimated 2005 ABS populations for each division (denominator).

The timeliness of reporting notifiable mosquito-borne diseases was calculated by quantifying the time lag from onset of disease to the public health unit notification received date. Where onset date was not supplied, the earliest date of specimen date, or notification date was used.

Sentinel chicken surveillance data for flaviviruses and sentinel pig surveillance data for Japanese encephalitis virus are reported.

Results

Alphaviruses

During this reporting period, there were 8,387 notifications of mosquito-borne disease (MBD) reported in Australia, which was twice the number of notifications reported for the last season. Overall, total MBD notifications during 2005–06 were the second highest on record and associated with increases in BFV and RRV notifications. The highest season on record was observed in 1995–96 with approximately 9,210 notifications of MBD reported.

RRV infections accounted for 66 per cent (n=5,515) of notifications with an onset in 2005–06, along with BFV infections (23%, n=1,895) and malaria (9%, n=731) (Figure 1).

Figure 1. Notifications of select mosquito-borne diseases, Australia, 1 July 2000 to 30 June 2006, by season of onset

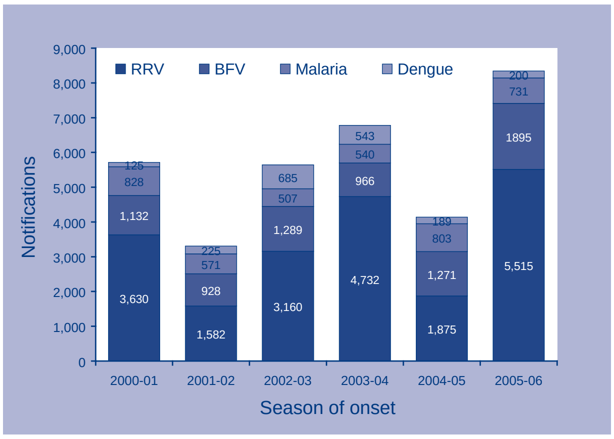
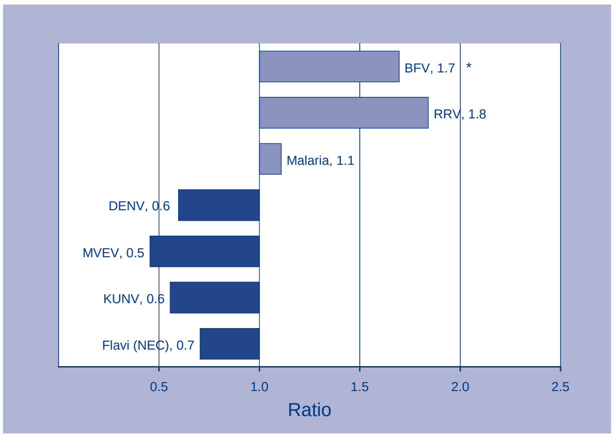


Figure 2 shows the ratio of BFV, RRV and malaria notifications for 2005–06 compared with the five-year mean. BFV notifications during 2005–06 exceeded two standard deviations above the five-year mean. Contributing factors to unusually high BFV notifications include an increase in vector numbers during spring, more active surveillance and clinical testing for BFV in some jurisdictions and the dual reporting of BFV and RRV notifications by some jurisdictions. An analysis of this is contained in the dual reporting of BFV and RRV section.

Figure 2. Ratio of 2005–06 notifiable mosquito-borne disease activity to mean of previous five years

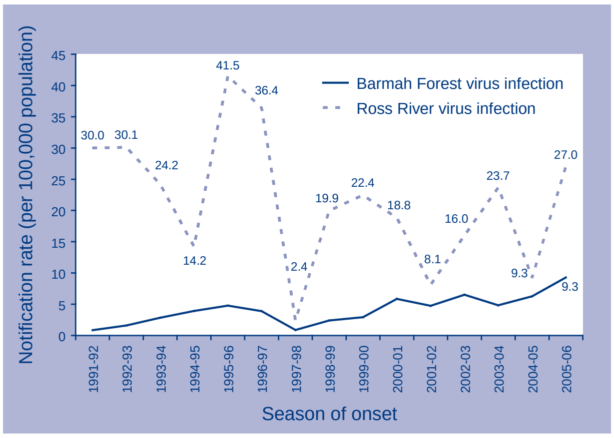


* Above 2 standard deviations.

No Japanese encephalitis virus infection cases in 2005-06.

The national notification rate for BFV in 2005–06 was 9.3 cases per 100,000 population (Figure 3) which was the highest notification rate for BFV since the commencement of the nationalised reporting of BFV in 1991. The national notification rate for RRV was 27 cases per 100,000 population, the highest reported notification rate for RRV since 1996–97.

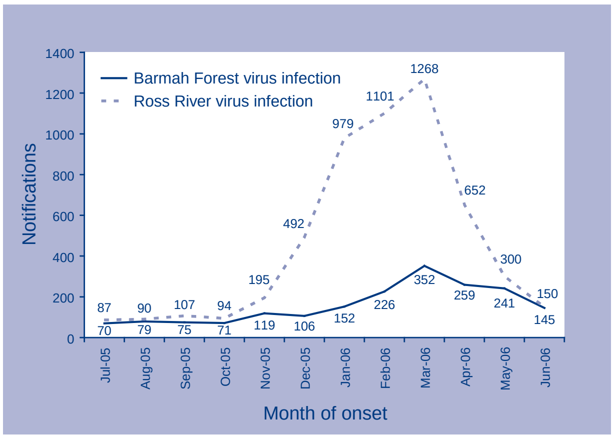
Figure 3. Crude annual rate of Barmah Forest virus and Ross River virus infections notifications, Australia, 1 July 1991 to 30 June 2006, by season of onset



These high notification rates were associated with a wet spring in 2005 in inland and coastal areas which produced favourable conditions for mosquito breeding.

During the 2005–06 season, the highest number of notifications for BFV and RRV was received in March (Figure 4). BFV notifications peaked earlier than in 2005 (April–May). The peak of RRV notifications (n=1268) in March 2006 was more than two and a half times the peak in March 2005.

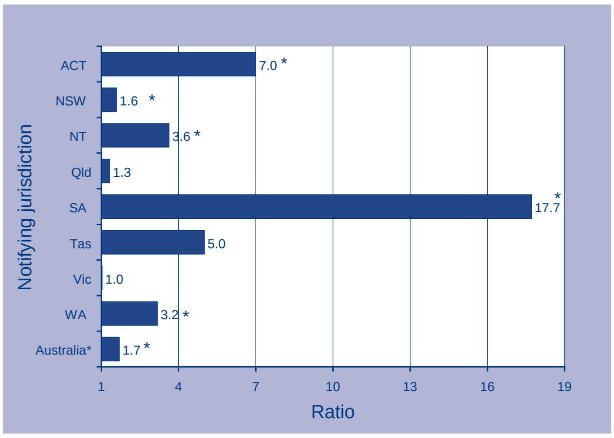
Figure 4. Barmah Forest virus infection and Ross River virus infections notifications, Australia, 1 July 2005 to 30 June 2006, by month of onset



Barmah Forest virus infections

During 2005–06, all jurisdictions except Victoria reported BFV activity above the five-year mean (Figure 5). Notifications of BFV from the Australian Capital Territory, New South Wales, the Northern

Figure 5. Ratio of Barmah Forest virus infection notifications to mean of previous five years, Australia, 1 July 2005 to 30 June 2006, by state or territory



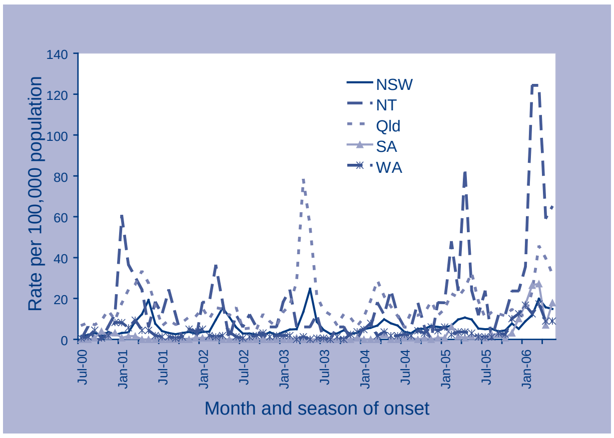
* Above 2 standard deviations.

Territory, South Australia and Western Australia, exceeded two standard deviations above the five-year mean. South Australia notified more than 17 times its five-year mean. This increase may be attributable to a change in surveillance practice from December 2005, when the Communicable Disease Control Branch, South Australia recommended that clinicians consider testing for both BFV and RRV if an arbovirus infection was suspected (Jane Raupach, personal communication).

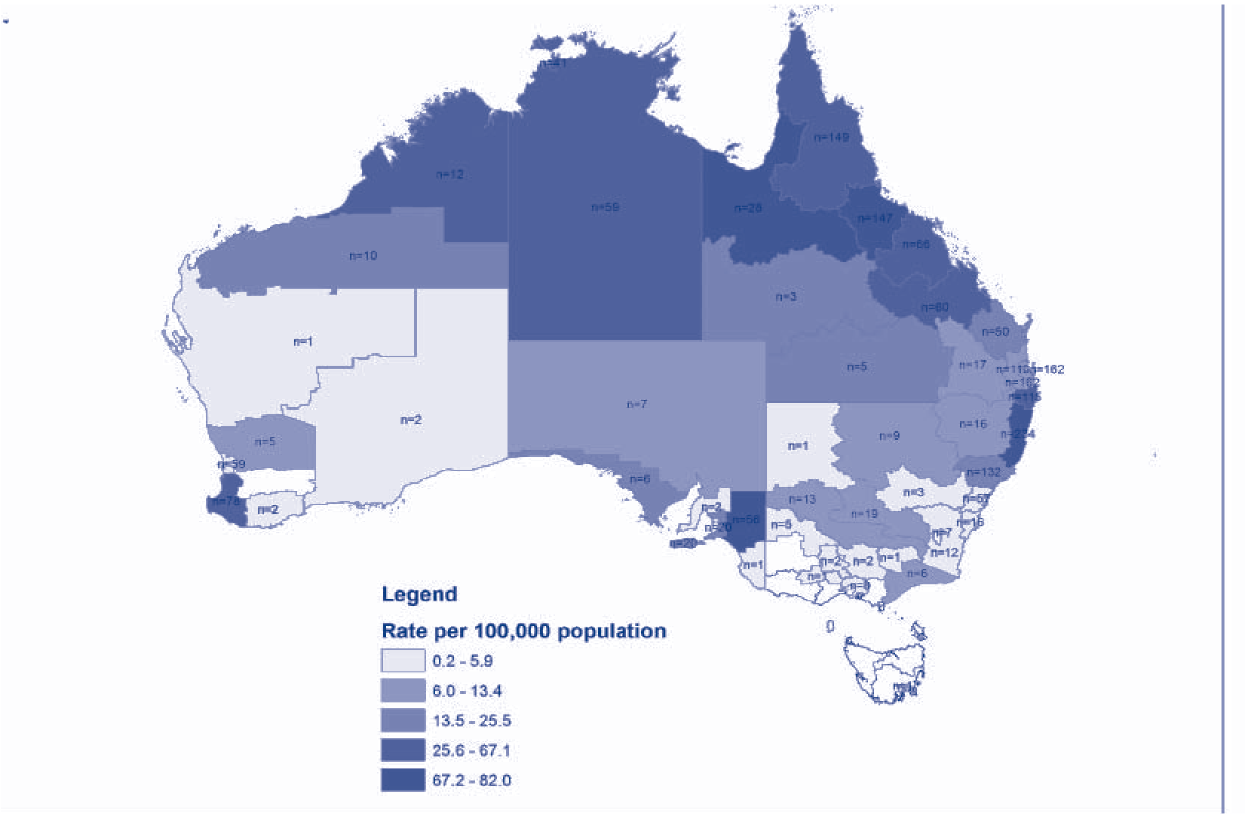
The highest rates of BFV notifications in Australia during 2005–06 were reported from Northwest Queensland (81.9 notifications per 100,000 population) and the Murray Lands in South Australia (81.5 notifications per 100,000 population) (Map 1). The majority of cases in the Murray Lands region occurred in the Coorong lower lakes area. The increase in BFV incidence for 2005–06 in this wetlands area was associated with the high abundance of *Aedes camptorhynchus* mosquitoes (Craig Williams, unpublished data). There is also evidence that elevated Culex australicus and Culex globocoxitus mosquito abundance in the Coorong lower lakes area during the three months preceding an outbreak is predictive of BFV activity, suggestive of the possible involvement of these vectors in an amplification cycle. Moderately high rates of BFV notifications were reported from Northern Queensland (71.5 notifications per 100,000 population) and from the Mid-North Coast area of New South Wales (79.3 notifications per 100,000 population). New South Wales reported the largest documented outbreak of BFV in Australia during this season.[24]

All states and territories reported peak notification rates of BFV in March 2006 (Figure 6). The Northern Territory notified the highest rate of BFV on record (124.3 cases per 100,000 population) during February and March 2006. Queensland reported

Figure 6. Annualised notification rate for Barmah Forest virus infections, select jurisdictions, 1 July 2000 to 30 June 2006, by state or territory



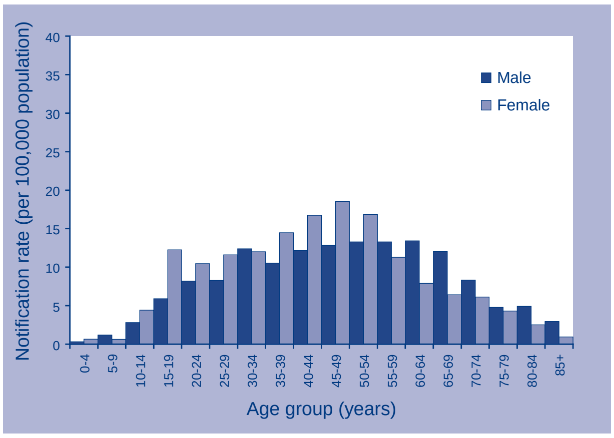
Map 1. Notifications and notification rates of Barmah Forest virus infection, Australia, 1 July 2005 to 30 June 06, by Statistical Division of residence



the second highest rate of BFV (45.7 cases per 100,000 population). South Australia also reported its highest ever BFV notification rate during March 2006 (27.2 cases per 100,000 population).

The national notification rate of BFV was highest in the 45–49 year age group (Figure 7). The highest notification rates were in females in the 45–49 year age group (18.5 cases per 100,000 population) and males in the 60–64 year age group (13.4 cases per 100,000 population). Notification rates were generally higher in females in the age range 15–54 years than males in the equivalent age groups.

Figure 7. Notification rate for Barmah Forest virus infections, Australia, 1 July 2005 to 30 June 2006, by age group and sex



In general, the age and sex distribution pattern for New South Wales (Figure 8) was similar to the pattern observed for the whole of Australia (Figure 7). Queensland (Figure 9) had higher age- and sex-specific notification rates than New South Wales, with males tending to have higher notification rates

Figure 8. Notification rate for Barmah Forest virus infections, New South Wales, 1 July 2005 to 30 June 2006, by age group and sex

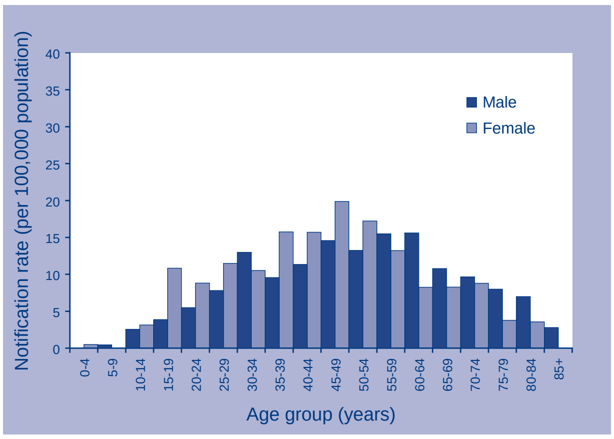
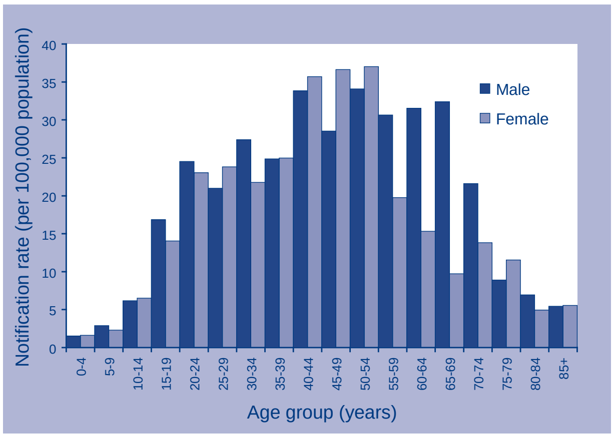
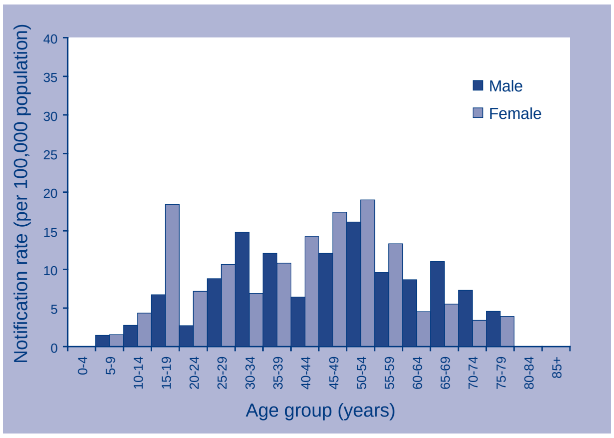


Figure 9. Notification rate for Barmah Forest virus infections, Queensland, 1 July 2005 to 30 June 2006, by age group and sex



than females in the 40–54 year age range. Western Australia (Figure 10) and the Northern Territory (Figure 11) displayed different age and sex distribution patterns of BFV notifications, with characteristically higher female-specific notification rates for many age groups. It is likely that small population sizes in age- and sex-specific age groups in these jurisdictions have affected the reporting rates (as small changes in the numerator lead to large changes in the overall rate).

Figure 10. Notification rate for Barmah Forest virus infections, Western Australia, 1 July 2005 to 30 June 2006, by age group and sex



In Western Australia, notifications in females in the 50–54 year age group (n=13) had the highest BFV age- and sex-specific notification rate (Figure 10). The Northern Territory reported high female notification rates in the 35–39 year (n=10, 123.6 cases per 100,000 population), the 45–49 year (n=9, 131.9 cases per 100,000 population), and the 60–74 year age groups (Figure 11). The highest age-specific BFV notification rate in the Northern

Figure 11. Notification rate for Barmah Forest virus infections, Northern Territory, 1 July 2005 to 30 June 2006, by age group and sex

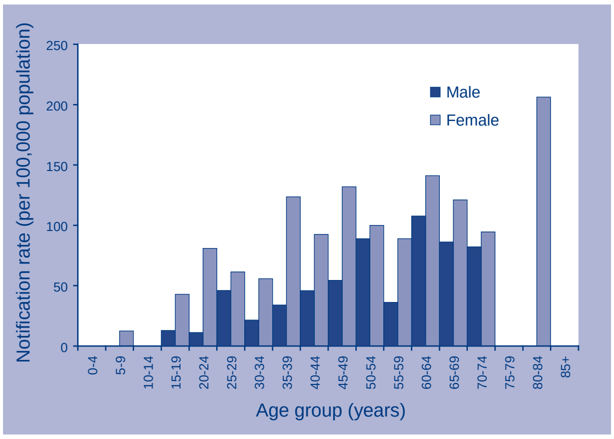
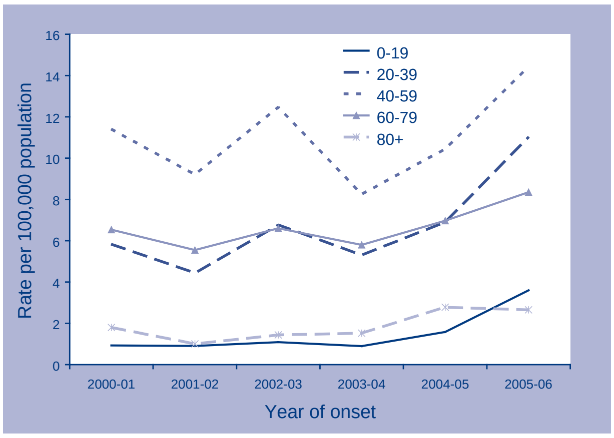


Figure 12. Trends in Barmah Forest virus infection notification rates, Australia, 1 July 2005 to 30 June 2006, by age group



Territory was observed in the 60–64 year age group (n=4 males, 4 females, 122.2 cases per 100,000 population). An extremely high female notification rate (206.2 cases per 100,000 population) in the 80–84 year age group was attributable to one notification reported in a relatively small age- and sex-specific population size (485 persons).

The age-specific rate of BFV notifications in 2005–06 changed significantly with a shift toward higher rates in children, teenagers and young adults when compared to the previous five seasons (Figure 12). The age-specific rate of BFV infection in the 0–19 year age range (3.6 notifications per 100,000 population) was over three times the five-year average (1.1 notifications per 100,000 population).

Timeliness of Barmah Forest virus infection notifications

The timeliness of BFV notifications is shown in Figure 13. In 2005–06, it took 8.5 days for 10 per cent of BFV notifications (n=1,238) and 106 days for 90 per cent of BFV notifications (n=1,886) from disease onset to be notified to public health units. The fastest notification times for the 10–50 percentiles were observed in 2002–03 and 2003–04.

Ross River virus infections

Historically, peaks in RRV notifications occur every four years (Figure 3). During 2005–06, all jurisdictions except Tasmania reported RRV activity above the five-year mean for their jurisdiction (Figure 14). Notifications of RRV from New South Wales and South Australia exceeded two standard deviations from the five-year mean for these jurisdictions. The peak notification rates for the Northern Territory (455.6 cases per 100,000 population) and South Australia (89.5 cases per 100,000 population) were

Figure 13. Timeliness of Barmah Forest virus infection notifications, Australia, 1 July 2000 to 30 June 2006, by percentile

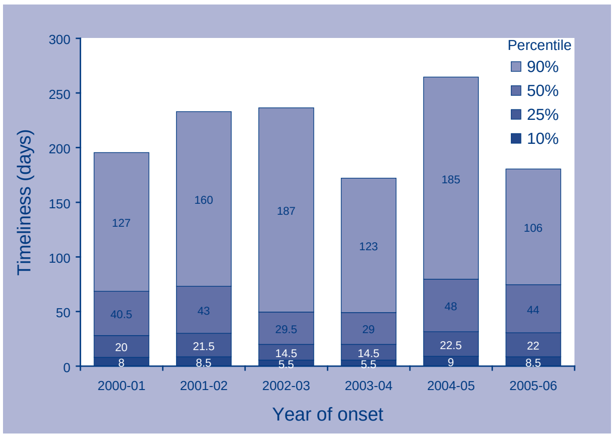
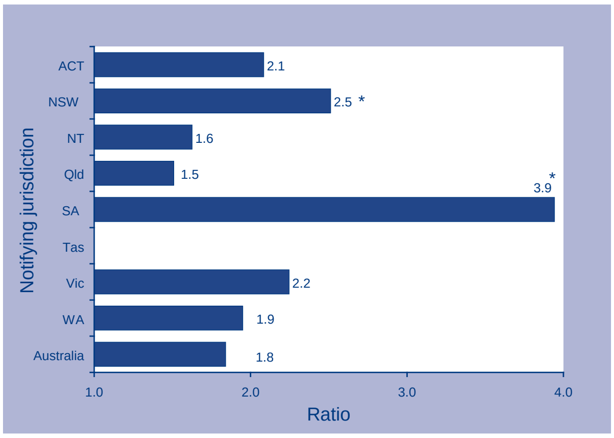


Figure 14. Ratio of Ross River virus infection notifications to mean of previous five years, Australia, 1 July 2005 to 30 June 2006, by state or territory



* Above 2 standard deviations.

reported in January 2006 (Figure 15). Queensland (45.7 cases per 100,000 population), South Australia (27.2 cases per 100,000 population), New South Wales (19.8 cases per 100,000 population) and Western Australia (17.3 cases per 100,000 population) reported peak notification rates in March 2006.

The highest rates of RRV notifications in Australia during 2005–06 were reported from the Kimberley region of Western Australia (218.2 notifications per 100,000 population), the Eyre region (193.3 notifications per 100,000 population) and the Murray Lands region (157.1 notifications per 100,000 population) of South Australia (Map 2). Moderately high rates of RRV notification were reported throughout northern Australia, and from the Southwest region of Western Australia.

The rate of national notifications for RRV was highest in the 35–39 year age group (Figure 16). Females in the 45–49 year age group (52.3 cases per 100,000

Figure 15. Annualised notification rates for Ross River virus infection, select jurisdictions, 1 July 2000 to 30 June 2006, by state or territory

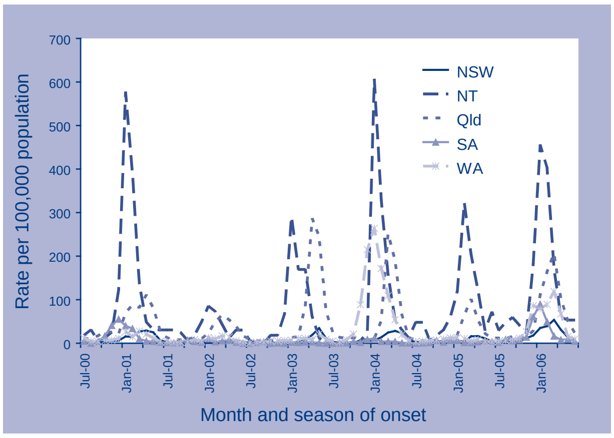
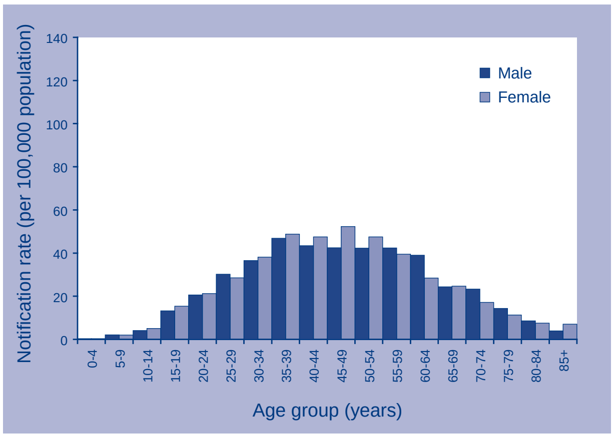
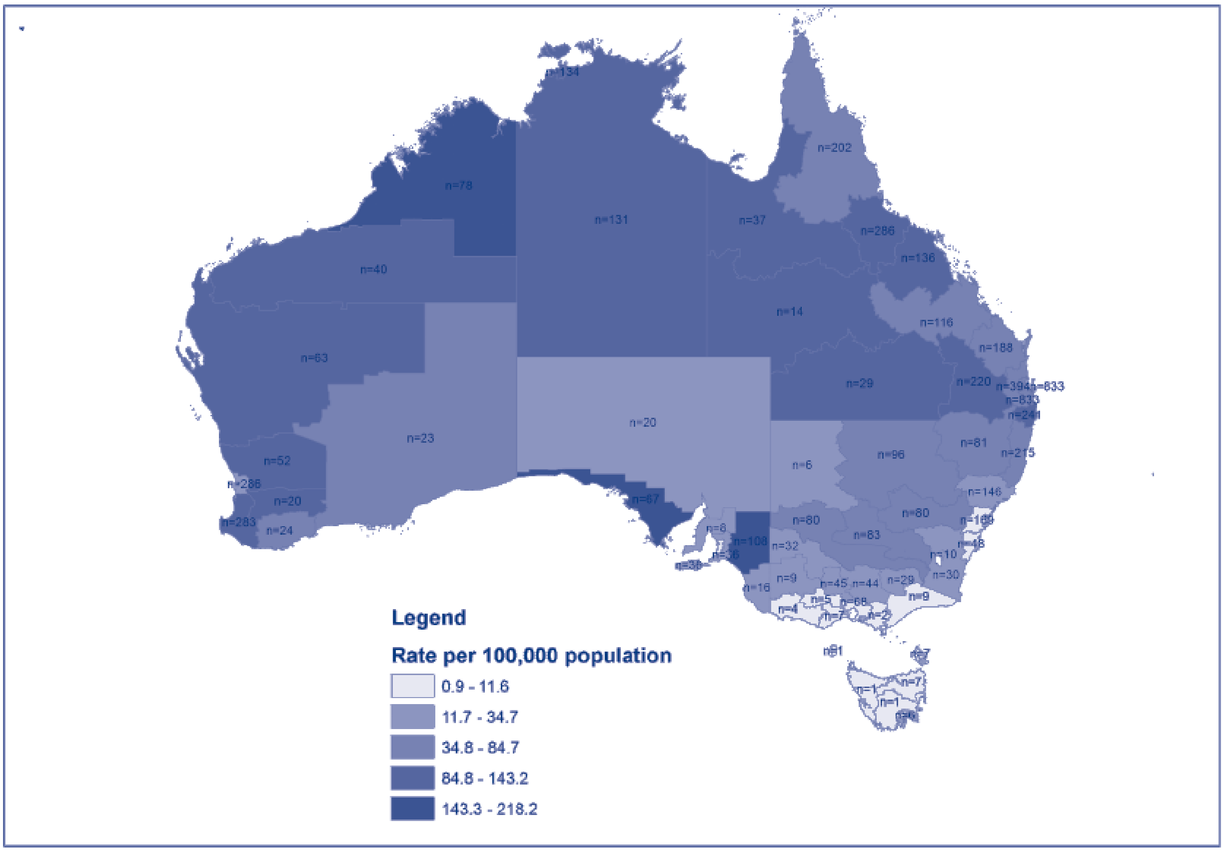


Figure 16. Notification rate for Ross River virus infections, Australia, 1 July 2005 to 30 June 2006, by age group and sex



Map 2. Notifications and notification rates of Ross River virus infections, Australia, 2005–06, by Statistical Division of residence



population) and males in 35–39 year age group (46.9 cases per 100,000 population) had the highest national age- and sex-specific notification rates.

In general, New South Wales (Figure 17) and Western Australia (Figure 18) showed similar age and sex distribution patterns to Australia. Age- and sex-specific notification rates of RRV from Western Australia were approximately twice the RRV notification rates from New South Wales.

Figure 17. Notification rate for Ross River virus infections, New South Wales, 1 July 2005 to 30 June 2006, by age group and sex

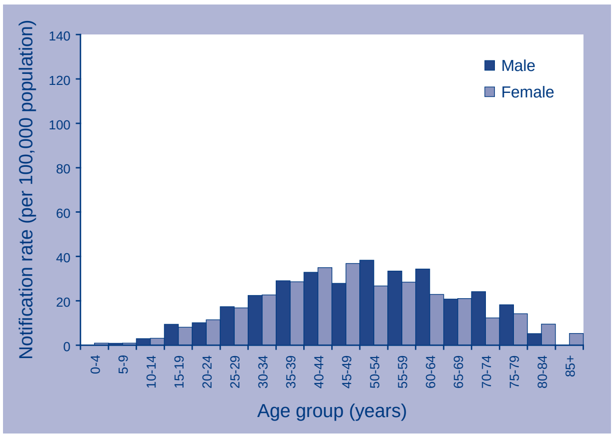
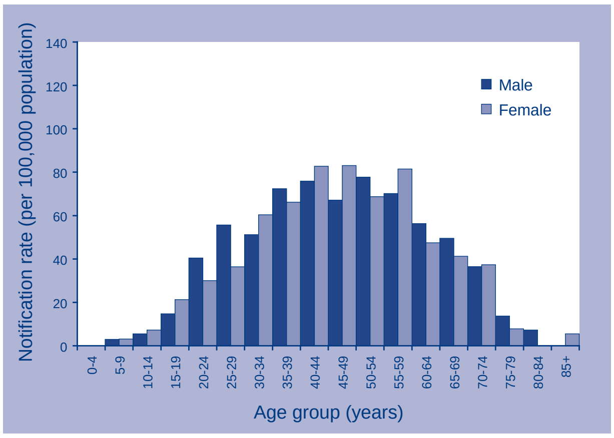
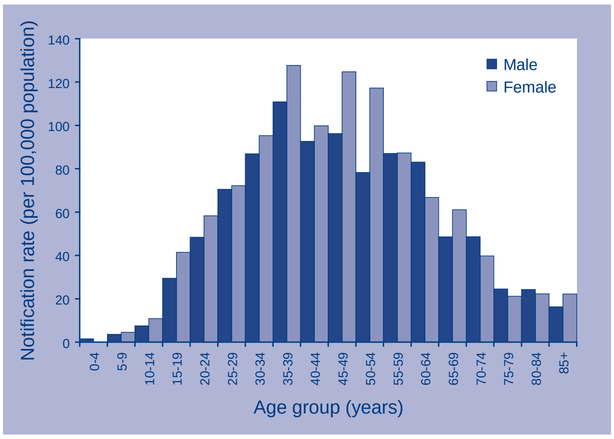


Figure 18. Notification rate for Ross River virus infections, Western Australia, 1 July 2005 to 30 June 2006, by age group and sex



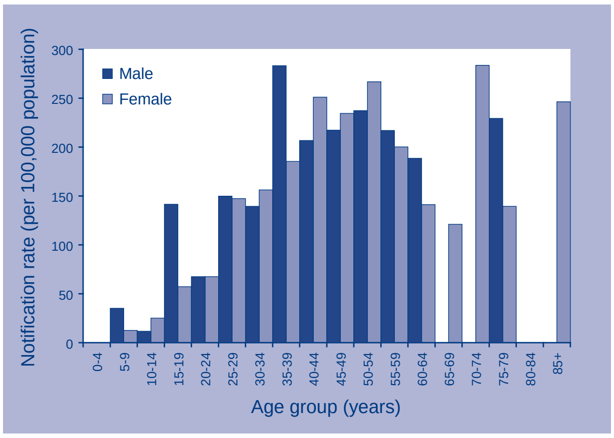
Notifications of RRV from Queensland (Figure 19) were highest in the 35–39 year age group (119.4 cases per 100,000 population). Notifications and notification rates in female-specific age groups were noticeably higher than male cohorts in Queensland for the 35–39 year age group (n=184, 127.7 cases per 100,000 population), 45–49 year age group (n=187, 124.7 cases per 100,000 population) and 50–54 year age group (n=152, 117.2 cases per 100,000 population).

Figure 19. Notification rate for Ross River virus infections, Queensland, 1 July 2005 to 30 June 2006, by age group and sex



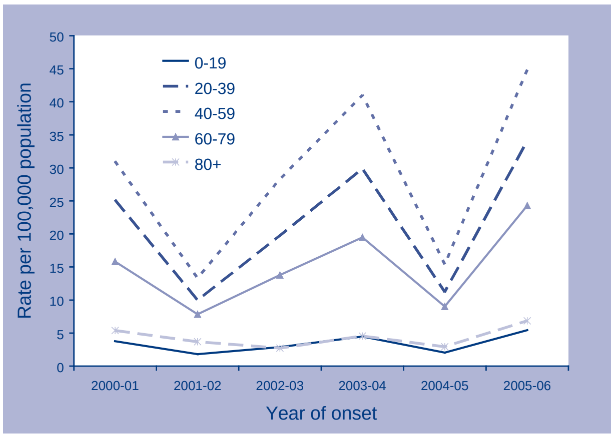
The Northern Territory overall had very high rates of RRV notifications, with very high age- and sex-specific peaks, some of which are due to small increases in the number of cases leading to large changes in the overall rate in this small population (Figure 20). Males in the 15–19 year age group had extremely high RRV notifications and notification rates (n=11, 141.5 cases per 100,000 population) when compared to either younger males or similarly aged females. Another high age specific peak was observed in the male 35–39 year age group (n=25, 283.3 cases per 100,000 population).

Figure 20. Notification rate for Ross River virus infections, Northern Territory, 1 July 2005 to 30 June 2006, by age group and sex



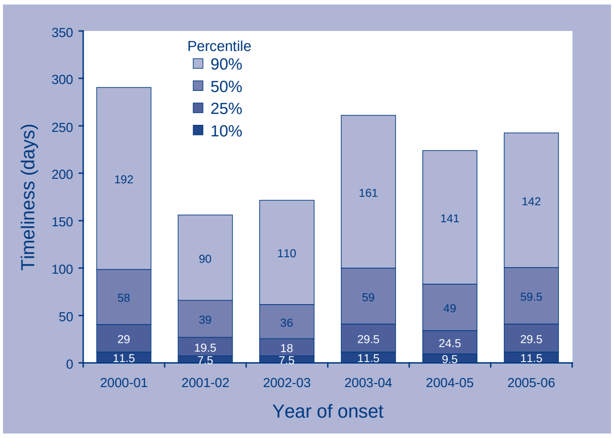
The age-specific rates for RRV notifications observed during this season were the highest on record since 2000. The overall age groups of the susceptible populations have not changed since 2000 (Figure 21).

Figure 21. Trends in Ross River virus infections notification rates, Australia, 1 July 2005 to 30 June 2006, by age group



The timeliness of RRV notifications is shown in (Figure 22). For this MBD season, 11.5 days elapsed between onset of disease and for 10 per cent of RRV notifications (n=4,031) to be reported to public health units. The fastest reporting of RRV notifications was observed in 2001–02 and 2002–03 for all percentiles.

Figure 22. Timeliness of Ross River virus infections notifications, Australia, 1 July 2000 to 30 June 2006, by percentile



Dual reporting of Barmah Forest virus infections and Ross River virus infections notifications

During 2005–06, South Australia reported that it was observing a larger proportion of BFV notifications which were also positive for RRV. These were also notified resulting in a dual national notification of BFV and RRV. Further investigations by the National Arbovirus and Malaria Advisory Committee (NAMAC) and the Public Health Laboratory Network (PHLN) have revealed that the dual notification of BFV and RRV may be linked to the cross-reactivity of sera in both in-house and commercial assay kits. PHLN has advised that caution should be exercised when interpreting the current reporting and notification of BFV in Australia, and it is considering revising the laboratory case definition by increasing the cut-off titre to improve the specificity.

Data in the NNDSS is de-identified. However, it is possible to estimate what proportion of BFV notifications have a RRV notification (and vice-versa) by matching notifications with the same date of birth, sex, residential postcode and onset date. The incidence of a true dual BFV and RRV infection is unknown although it has been estimated as a rare event (NAMAC members, personal communication). If the dual BFV notifications are excluded from epidemiological analyses, only BFV notifications from Queensland in 2005–06 (n=478) drop below the activity of the previous five-year mean (570), but the overall BFV activity for Australia remains above the five-year mean.

Barmah Forest virus infection notifications with a corresponding Ross River virus infection notification

Table 1 shows that in 2005–06, 12 per cent (n=465 of 3,894) of national BFV notifications correspond to a RRV notification with the same demographic and geographic attributes. By this method the frequency of dual notifications appears to have increased steadily since 2000. Some jurisdictions such as the Northern Territory, Queensland, and Western Australia are reporting increasingly higher numbers of dual BFV and RRV notifications each reporting year. In 2000–01, Victoria reported that 14 per cent of BFV notifications had a corresponding RRV notification, but in subsequent years there have been no further dual notifications from Victoria. South Australia has only recently been reporting dual notification after a hiatus of dual notifications since 2000–01, perhaps marking a change in public health laboratory practice. It is not known what proportion of these jurisdictional trends in reporting dual notifications are related to increasingly greater dependence on a specific type or brand of serological test.

Ross River virus infection notifications with a corresponding Barmah Forest virus infection notification

Table 2 shows nationally that only 3 per cent of RRV notifications have a corresponding BFV notification, but this has risen steadily from 2000–01. Some jurisdictions in particular such as New South Wales, the Northern Territory, Queensland, and South Australia are notifying more cases of dual RRV and BFV notifications each year. Western Australia and Victoria are reporting the dual RRV and BFV notifications in the same proportions each year.

Table 1. Number and proportion of Barmah Forest virus infections with corresponding Ross River virus infection, Australia, 1 July 2000 to 30 June 2006, by year of onset and state or territory

State or territory	2000–01			2001–02			2002–03			2003–04			2004–05			2005–06		
	dual n	BFV n	BFV % dual	dual n	BFV n	BFV % dual	dual n	BFV n	BFV % dual	dual n	BFV n	BFV % dual	dual n	BFV n	BFV % dual	dual n	BFV n	BFV % dual
ACT	0	2	0	0	0	0	0	1	0	0	2	0	0	2	0	0	7	0
NSW	9	375	2	3	378	1	15	423	4	13	438	3	9	375	2	62	626	10
NT	2	33	6	1	25	4	0	18	0	5	44	11	2	33	6	8	98	8
Qld	19	602	3	17	418	4	86	805	11	53	676	8	19	602	3	326	2,398	14
SA	2	17	12	0	4	0	0	1	0	2	20	10	2	17	12	24	289	8
Tas	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0
Vic	3	21	14	0	58	0	0	16	0	0	22	0	3	21	14	1	73	1
WA	5	81	6	2	45	4	2	25	8	2	69	3	5	81	6	44	401	11
Total	40	1,132	4	23	928	2	103	1,289	8	75	1,271	6	40	1,132	4	465	3,894	12

Table 2. Number and proportion of Ross River virus infections with corresponding Barmah Forest virus infection, Australia, 1 July 2000 to 30 June 2006, by year of onset and state or territory

State or territory	2000–01			2001–02			2002–03			2003–04			2004–05			2005–06		
	dual n	RRV n	RRV % dual	dual n	RRV n	RRV % dual	dual n	RRV n	RRV % dual	dual n	RRV n	RRV % dual	dual n	RRV n	RRV % dual	dual n	RRV n	RRV % dual
ACT	0	14	0	0	0	0	0	0	0	0	4	0	0	14	0	0	10	0
NSW	9	773	1	3	217	1	15	453	3	13	441	3	9	773	1	62	1,275	5
NT	2	233	1	1	71	1	0	134	0	5	180	3	2	233	1	8	267	3
Qld	19	1,717	1	17	944	2	86	2,391	4	53	1,013	5	19	1,717	1	326	7,561	4
SA	2	271	1	0	57	0	0	20	0	2	50	4	2	271	1	24	773	3
Tas	0	11	0	0	120	0	0	2	0	0	5	0	0	11	0	0	46	0
Vic	3	375	1	0	43	0	0	14	0	0	38	0	3	375	1	1	594	0
WA	5	236	2	2	130	2	2	146	1	2	144	1	5	236	2	44	3,254	1
Total	40	3,630	1	23	1,582	1	103	3,160	3	75	1,875	4	40	3,630	1	465	13,780	3

Chikungunya virus infections

An outbreak of chikungunya virus (CHIKV) occurred in the south-east Indian Ocean region in early 2006, with an estimated two-thirds of the human population of Reunion Island infected. Travellers returning from outbreak areas have been diagnosed in Europe, Canada, the Caribbean, South America and the United States of America (USA).[25]

In March 2006, Victoria reported to NAMAC and the Communicable Diseases Network Australia, a case of CHIKV in a 59-year-old male visitor from Mauritius associated with the Commonwealth Games (Rodney Moran, personal communication). The case arrived in Australia on 7 March 2006, with an onset of illness on 10 March 2006 (lethargy, fever, arthralgia, myalgia, rash, headache, ankle arthritis). He was admitted to hospital on 12 March, improved and discharged 15 March 2006.

In New South Wales, there were three confirmed cases of CHIKV associated with attendance at the Commonwealth Games all reported from one laboratory. All three were acquired in Mauritius (Linda Hueston, personal communication).

Flaviviruses

The Sentinel Chicken Programme is a surveillance network involving New South Wales, the Northern Territory, Victoria and Western Australia, and is designed to detect flavivirus activity (including the endemic arboviruses MVEV and KUNV).[26] Table 3 shows notifications of flavivirus from 1 July 2005 to 30 June 2006, by state or territory.

Northern Territory

The Northern Territory sentinel chicken program commenced in January 1992 and replaced an earlier program run by the Australian Quarantine and Inspection Service (AQIS). Sentinel chicken flocks in the Northern Territory are maintained, bled and analysed for flavivirus in a combined program between the Northern Territory Department of Health and Community Services, the Northern Territory Department of Business Industry and Resource Development (DBIRD), and volunteers.

Map 3 shows that the sentinel chicken flocks are presently at Darwin urban (Leanyer), Darwin rural (Howard Springs), Beatrice Hill (Coastal Plains Research Station), Kakadu (Jabiru), Katherine, Nhulunbuy, Tennant Creek, Alyangula, Nathan River and Alice Springs (Ilparpa and Arid Zone Research Station). DBIRD officers or volunteers usually bleed flocks once a month and the samples are sent to the Northern Territory Department of Business Industry and Resource Development for specific testing for MVEV and KUNV. Sometimes for operational reasons, chickens are not bled during a schedule month and hence seroconversion shown in the next bleed could have occurred in the previous month. When chickens from a flock show new antibodies to MVEV during a prime risk period, a media warning is issued for the region for the risk period. These warnings advise the public of the need to take added precautions to avoid mosquito bites.

Chickens are replaced at least annually and more frequently if birds die or if large proportions seroconvert. They are well positioned to detect flavivirus

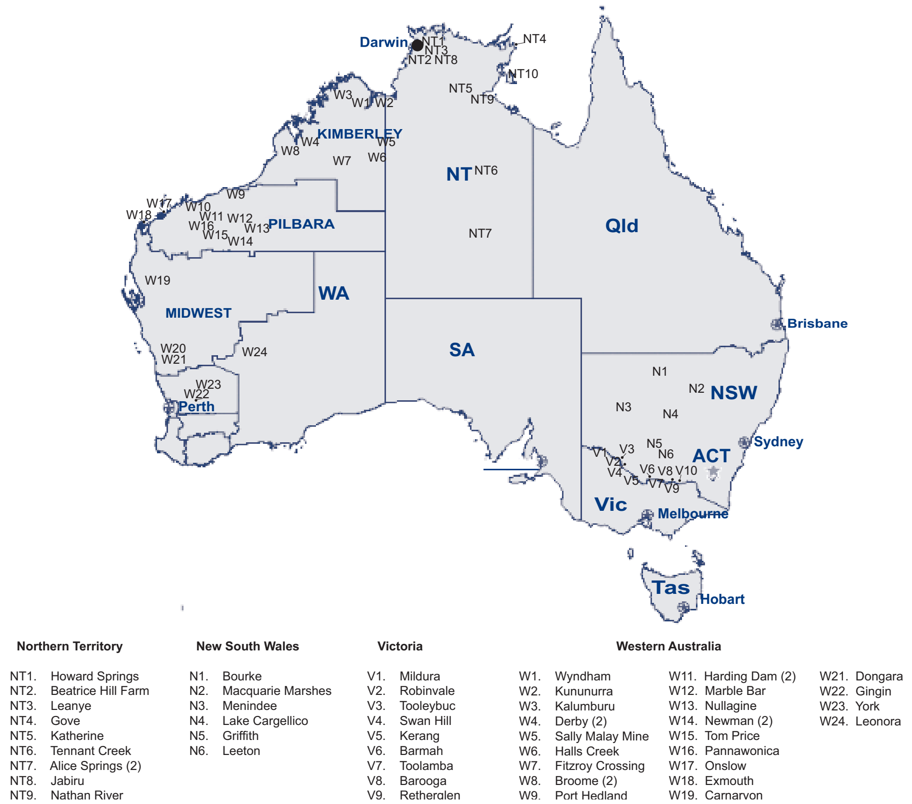
Table 3. Number and rate of flavivirus notifications, 1 July 2005 to 30 June 2006, Australia, by state or territory

State or territory	DENV		Flavivirus NEC		KUNV		MVEV	
	n	Rate	n	Rate	n	Rate	n	Rate
ACT	7	NA	0	NA	0	0	0	0
NSW	54	NA	2	NA	0	0	0	0
NT	16	NA	0	NA	0	0	0	0
Qld	79	NA	28	NA	0	0	0	0
SA	10	NA	0	NA	0	0	0	0
Tas	0	NA	0	NA	0	0	0	0
Vic	14	NA	13	NA	0	0	0	0
WA	20	NA	0	NA	2	0.1	1	0
Australia	200	NA	43	NA	2	0.01	1	<0.01

* Rate per 100,000 population.

NA Not applicable, rates not calculated since, most cases of dengue (outside Queensland) and flavivirus NEC were acquired overseas or had an unknown country of acquisition.

Map 3. Sentinel chicken testing sites, Australia 2005–06



activity near the principal towns of the Northern Territory and hence provide timely and accurate indication of risk to people in those towns.

In the 2005–06 season, MVEV activity was detected in Howard Springs in June, Leanyer in May, Adelaide River in March (probably February seroconversion) and June, Katherine in June, Tennant Creek in June (probably May seroconversion), Jabiru in May and Nathan River in June.

The MVEV total seroconversions this year (n=15) was similar to last year (n=13), with most seroconversion this year (n=4) occurring in the Adelaide River, followed by the Nathan River flock (n=3). Most seroconversion this year occurred in June (n=8) while the long-term seroconversion peak occurs in May closely followed by March and then February. The high number of seroconversions and the number of flocks seroconverting in June is most likely due to the extended wet season in the Northern Territory in 2005–06.

There were no seroconversions in the two Alice Springs flocks, most probably due to the below average summer rainfall and low vector numbers. In addition, the successful effluent swamp drainage and better effluent management from nearby sewage facilities in the Ilparpa area, have led to an overall reduction in vector numbers near the Alice Springs outskirts during summer.

There were also no seroconversions in the Nhulunbuy and the Alyangula flock. However, the Alyangula flock only commenced in April 2006.

No human cases of MVEV disease were reported in the Northern Territory in 2005–06 and the last reported case was in March 2005 when a 3-year-old boy from a community in Arnhem Land had a relatively mild illness and made a complete recovery.

Kunjin virus activity was present throughout the Northern Territory, with seroconversion to KUNV in Darwin (Howard Springs) in May; Darwin (Leanyer) in April; Adelaide River in May and June; Katherine in April, May and June; and in Tennant Creek in April.

There has been a trend over the last 10 years to increasing numbers of seroconversions to KUNV, with this year's total (n=13) higher than last year (n=12) and the highest since the program started in 1992. Most seroconversions occurred in the Katherine (n=6) and Adelaide River (n=4) flocks. Seroconversions mostly occurred this year in May (n=6), while the long term peak is also in May, followed at a substantially reduced level in April.

The Northern Territory did not report any human cases of KUNV infection this year. The last reported KUNV case from the Northern Territory was in a 23- year-old female from Alice Springs in May 2001.

Western Australia

Sentinel chicken flocks in Western Australia are maintained, bled and analysed for specific antibodies to MVEV and KUNV in a combined program between The University of Western Australia, Western Australian Department of Health, local governments and community volunteers. Twenty-eight sentinel chicken flocks were located at major towns and communities in the Kimberley, Pilbara, Gascoyne, Goldfields, Midwest and Central Coastal regions of Western Australia. Environmental health officers or trained volunteers took blood samples from the chickens each fortnight from December to June (the major MVEV 'risk' season) and monthly at other times. Samples were tested by the Arbovirus Surveillance and Research Laboratory at the University of Western Australia. Sometimes for operational reasons, chickens were not bled fortnightly and a seroconversion detected in the next bleed may have occurred earlier.

Rainfall was generally above average for most of the 2005–06 wet season in the Kimberley, Pilbara and Interior regions. There was extensive flooding in the Kimberley, Pilbara, Gascoyne and Interior regions in March and/or April 2006.

More than 3,000 serum samples from the 28 flocks located in Western Australia were tested for antibodies to flaviviruses during 2005–06. Seroconversions to flaviviruses were detected in 5.5 per cent of the samples. Overall, flavivirus activity was very high during the 2005–06 season, and the majority of seroconversions were due to infection with MVEV. The first seroconversions were detected at Sally Malay, Wyndham and Derby in February 2006. Activity rapidly increased to include all major towns in the Kimberley region and continued through to June 2006 (and into the 2006–07 season). The first flavivirus seroconversion in the Pilbara region was a MVEV infection in a sentinel chicken at Tom Price in March 2006. During the ensuing months, MVEV activity was detected at all locations in the Pilbara except Port Hedland. However, KUNV activity was subsequently detected at Port Hedland in July 2006. One seroconversion to MVEV was detected in the Carnarvon sentinel chicken flock in June 2006. This is the furthest south that MVEV has been detected since August 2000, when there was an extensive and prolonged period of MVEV associated with Cyclone Steve.[27] Unidentified flavivirus infections were detected at a number of locations in the Kimberley and Pilbara regions, and are possibly due to activity of other flaviviruses that are occasionally isolated from mosquitoes collected in northern Western Australia.

Three flavivirus human cases (Table 3) were reported from Western Australia during the 2005–06 season (Dr David Smith, PathWest, personal communication). The first case was reported in a 27-year-old woman from Broome who acquired a KUNV infection just prior to March 2006. There was one case of KUNV infection (with polyarthralgia) in a Kununurra resident in April 2006. One case of encephalitic MVEV infection requiring hospitalisation was diagnosed in an 8-year-old female from Broome in June 2006. Seroconversions to MVEV or KUNV in sentinel chickens provided advance warning of flavivirus activity in these regions.

The West Australian Department of Health initially issued health warnings on 24 February 2006, of increased risk of MVEV to residents and visitors to the north or east Kimberley region, following seroconversions to MVEV in the north-east Kimberley region. Additional warnings were issued on 7 April after heavy rainfall in the Pilbara region and the detection of MVEV; on 1 May following increased MVEV activity in the Pilbara, the detection of KUNV at Exmouth and continued heavy rainfall in the Pilbara and Gascoyne; and on 15 June after MVEV was detected in the sentinel chicken flock at Carnarvon. The warnings advised residents and travellers to the regions of the increased risk of disease and the need to take precautions to avoid mosquito bites.

New South Wales

Samples from six sentinel chicken sites were tested weekly for KUNV and MVEV antibodies in New South Wales from mid-October 2005 to the end of April 2006. There were no seroconversions to MVEV or KUNV during this period. There were no human cases reported from New South Wales for either MVEV or KUNV. The last reported case of KUNV from New South Wales was notified in May 2001 in a 58-year-old female from Griffith. There have been no recorded cases of MVEV to date in NNDSS from New South Wales.

Victoria

Samples from sentinel chicken flocks located throughout northern inland Victoria (10 sites along the Murray River, Map 3) were tested weekly for flavivirus antibodies from 1 November 2005 to early March 2006. No KUNV or MVEV activity was detected in any of the samples. There were no human cases of KUNV or MVEV reported from Victoria during 2005–06. The last reported case of

KUNV infection in Victoria was in October 2004. There have been no recorded cases of MVEV in NNDSS from Victoria.

Queensland

There were no sentinel chicken flocks in Queensland during 2005–06 although flocks were maintained in 2002–03. There were no cases of KUNV or MVEV reported by Queensland during 2005–06. The last reported KUNV cases from Queensland were three sporadic cases notified in July 2004, December 2004, and February 2005. The last reported MVEV case from Queensland was in a 3-year-old boy from Mount Isa in 2001.

Japanese encephalitis virus infections

Japanese encephalitis virus appears nearly annually in the Torres Strait in far northern Queensland, and threatens to invade the Australian mainland. Surveillance has involved the use of sentinel pigs that develop detectable viraemia and antibody titres to JEV.

The use of sentinel pigs on Badu Island was discontinued in 2006 on the recommendation by Queensland Health, who concluded that JEV incursions during the wet season will be an annual occurrence as far south as the central islands of the Torres Strait. In March 2006, an annual Northern Australia Quarantine Strategy (NAQS) survey of the Torres Strait and Northern Peninsula Area domestic livestock, detected JEV activity on Moa Island from blood samples obtained from juvenile domestic pigs.

AQIS, through the NAQS program, conducted monitoring for JEV for the 2006 wet season using sentinel pigs at Injinoo airport, Northern Peninsula Area, Cape York. The five sentinel pigs did not seroconvert and there was no evidence of transmission of JEV to the mainland in 2006 (based on results of testing at Queensland Health Scientific Services and the CSIRO Australian Animal Health Laboratory).

The use of pigs as a sentinel system poses a public health risk because pigs are amplifying hosts for JEV. A remote mosquito trap system does not have this risk and mosquito trapping on the Cape York peninsula has resulted in the first report of a mosquito isolate of JEV from the Australian mainland.[28] Ritchie (unpublished data) evaluated and compared a remote mosquito trap system with pigs for the surveillance of JEV on Badu and Moa islands in the Torres Strait and at Bamaga in northern Cape York Peninsula from 2002–2005. JEV was detected in mosquito collections each year but not for each trap type and no JEV was detected in trapped mosquitoes before detection in sentinel pigs. A remote mosquito trap system, employing stand alone traps and polymerase chain reaction for viral antigen detection was found to be a safe, economical way to detect arbovirus activity in these remote areas.

There were no human cases of JEV in Australia during 2005–06. The last reported JEV case was in February 2004, when Queensland notified that a 66-year-old male acquired JEV from Papua New Guinea. There have been nine other cases of JEV reported to NNDSS since 1995, although JEV was not nationally notifiable until 2001. Four of these notifications were reported in Torres Strait islanders from the Badu Island community, two of which were fatal (1995). The other locally-acquired JEV case was reported in a resident from the mouth of the Mitchell River, Cape York Peninsula, Queensland in 1998. The remaining four cases were reported as acquired from overseas countries.

Flavivirus infections (not elsewhere classified)

There were 43 flavivirus (not elsewhere classified or NEC) notifications during the 2005–06 season, of which 13 were acquired overseas. The source of acquisition was unknown for the remaining notifications.

Queensland reported 28 flavivirus (NEC) notifications; Victoria (n=13) and New South Wales (n=2). Of the 28 flavivirus infection (NEC) notifications from Queensland, there were six Kokobera and one Stratford virus. The flavivirus infection (NEC) notifications from Victoria and New South Wales were of unknown type.

Dengue virus infections

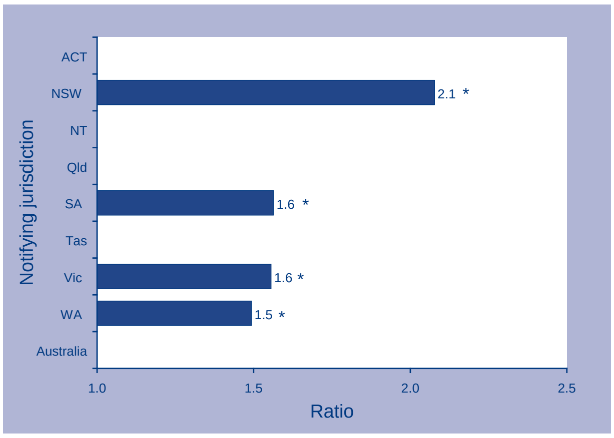
There were 200 notifications of DENV infections during the 2005–06 season. Table 4 shows that the cases were mainly from Queensland (n=79, 40%), New South Wales (n=54, 27%) and Western Australia (n=20, 10%). Notifications from New

Table 4. Locally acquired and imported dengue notifications, Australia, 1 July 2005 to 30 June 2006, by state or territory

Notifying jurisdiction	n	%
ACT	7	4
NSW	54	27
NT	16	8
Qld	79	40
SA	10	5
Tas	0	0
Vic	14	7
WA	20	10
Total	200	100

South Wales, South Australia, Victoria and Western Australia exceeded the five-year mean in each jurisdiction (Figure 23). Of the national DENV notifications notified, 46 per cent (n=92) were reported as imported, 43 per cent (n=86) were locally-acquired and 11 per cent (n=22) had an unknown source of acquisition.

Figure 23. Ratio of locally acquired and imported dengue notifications to mean of previous five years, Australia, 1 July 2005 to 30 June 2006, by state or territory

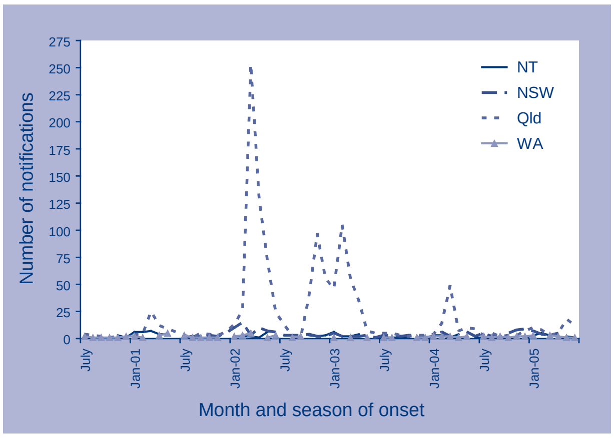


* Above 2 standard deviations.

Figure 24 shows that the number of DENV notifications received during the 2005–06 season was much lower than the previous three seasons. New South Wales, South Australia, Victoria and Western Australia reported DENV activity above the five-year mean.

There were two outbreaks of locally acquired DENV in Queensland during this season (Jeffrey Hanna, Scott Ritchie, personal communication). There were eight cases of DENV serotype 3 in Townsville from December 2005 – February 2006. In the Cairns and Gordonvale area, there were 19 cases of DENV serotype 2 up to 30 June 2006 with a peak in cases in May 2006 (Figure 24). The outbreak was finally controlled in September 2006 with a total of 29 cases (Jeffrey Hanna, Scott Ritchie, personal communication).

Figure 24. Dengue notifications (locally-acquired and imported cases), select jurisdictions, 1 July 2005 to 30 June 2006, by month and season of onset



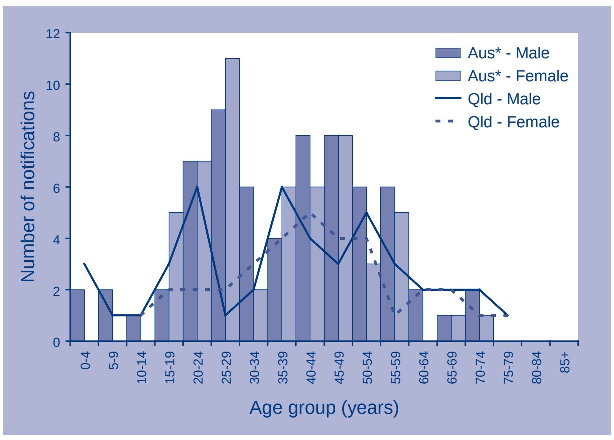
Of the 200 DENV notifications, dengue serotype 2 was reported in 16 per cent (n=31) of cases (Table 5). There were 15 cases of serotype 3 infection, 7 cases of serotype 1, and 5 cases of serotype 4. Serotype information was either not stated or unavailable for 71 per cent of the notifications (n=142).

Table 5. Dengue notifications (locally-acquired and imported cases), Australia, 1 July 2005 to 30 June 2006, by serotype

Serotype	n	%
Serotype 1	7	4
Serotype 2	31	16
Serotype 3	15	8
Serotype 4	5	3
Not typed/unknown	142	71
Total	200	100

Figure 25 shows that imported DENV notifications in Australia were most frequently reported in the 25–29 year age group (n=20, 17%) whereas in locally acquired cases from Queensland, this age group was rarely affected (n=3, 4%), with many of the locally acquired cases occurring in the 20–24 year age group (n=8, 10%) and the 35–54 year age groups (n=35, 44%).

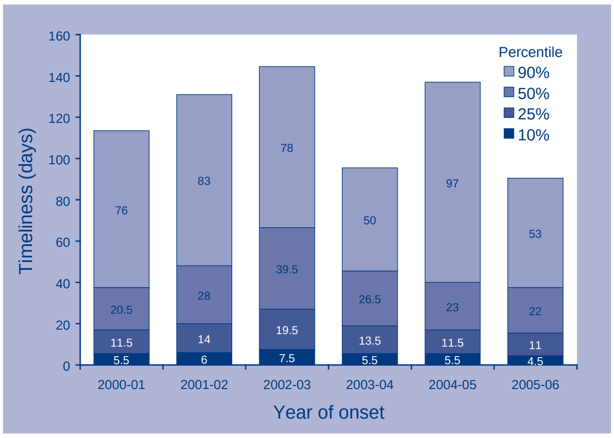
Figure 25. Dengue notifications, Queensland and Australia, 1 July 2005 to 30 June 2006, by age group and sex



* Excludes Queensland.

The timeliness of reporting DENV notifications is shown in Figure 26. During 2005–06, it took 4.5 days to notify 10 per cent of DENV notifications and 53 days to notify 90 per cent of notifications from onset of disease to receipt of notification by the public health unit. The late notification (50% >22 days) indicates that the risk of further transmission in areas with *Aedes aegypti* is high, particularly as the DENV replicates within the mosquito during an incubation period of 10–12 days.

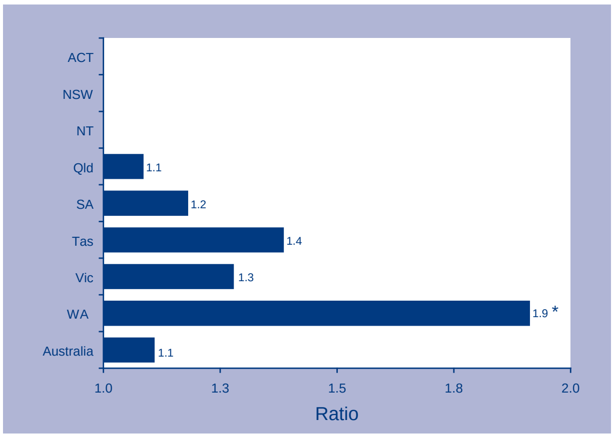
Figure 26. Timeliness of dengue notifications, Australia, 1 July 2000 to 30 June 2006, by percentile



Malaria

There were 731 notifications of malaria in Australia in the period 1 July 2005 to 30 June 2006. No reports of locally-acquired malaria were notified during the reporting period. Queensland reported the majority of cases (n=309, Table 6). Western Australia reported malaria notifications which exceeded two standard deviations above its five-year average (Figure 27). Victoria reported that a large number of malaria notifications in the period 2005–06 were acquired in Papua New Guinea (Rodney Moran, personal communication).

Figure 27. Ratio of malaria notifications to mean of previous five years, Australia, 1 July 2005 to 30 June 2006, by state or territory



* Above 2 standard deviations.

Figure 28 shows that the 2005–06 reporting period was the third largest for malaria notifications since 2000–01.

Figure 28. Number of notifications of malaria, Australia, 2000 to 2006, by year of onset

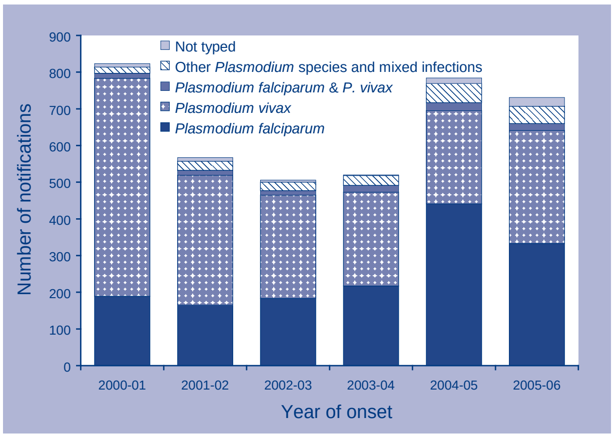


Table 6. Malaria notifications in Australia, 1 July 2000 to 30 June 2006, by parasite type

Infecting species	Year of onset						Last 5 year mean	Ratio 05–06/ 5 year mean
	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06		
Plasmodium falciparum	189	165	183	217	441	333	239	1.4
Plasmodium vivax	594	354	282	256	254	308	348	0.9
Plasmodium falciparum and *P. vivax*	14	13	12	18	22	19	16	1.2
Other *Plasmodium* species and mixed infections	17	25	23	27	52	47	29	1.6
Not typed	9	10	6	2	15	24	8	2.9
Total	823	567	506	520	784	731		

Overall, malaria notifications were highest in the young adult 20–24 year age group (Figure 29). This trend was also observed in years prior to 2004–05 (Figure 30).

Figure 29. Number of imported malaria notifications, Australia, 1 July 2005 to 30 June 2006, by age group and sex

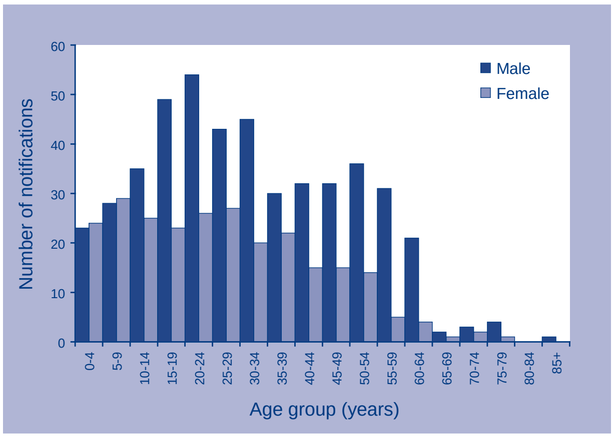
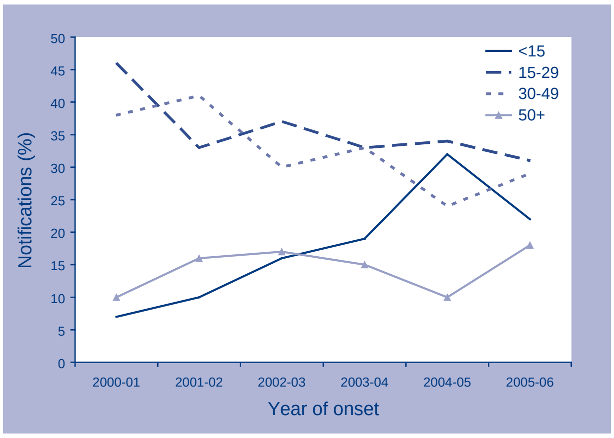


Figure 30. Trends in the age distribution of malaria notifications, Australia, 1 July 2000 to 30 June 2006, by age group



In the period 2005–06, the proportion of children under the age of 15 years notified with malaria was 22 per cent (n=164), but this was not as high as observed in 2004–05 when malaria notifications in this age group accounted for almost one third of all notifications for the first time since 1998. The trend in younger children represented in notifications has been discussed elsewhere and is related to refugee arrivals.[29]

More male notifications (n=471) than female notifications (n=253) were reported. Males in the 20–24 year age group were the largest reported sex-specific cohort whereas the largest reported numbers of female notifications were observed in the 5–9 year age group.

The infecting *Plasmodium* species was reported for 97 per cent of malaria notifications in 2005–06 (Table 6). The majority of the 731 malaria notifications were due to *P. falciparum* (45%, n=333) and *P. vivax* (42%, n=308) while other *Plasmodium* species or mixed *Plasmodium* species infections accounted for 6 per cent (n=47).

Figure 31 shows that in 2005–06 the proportion of notifications due to *P. falciparum* malaria (45%) decreased slightly from last year (56%) but was still 1.4 times the five-year mean for the same species. The number of hospital separations due to *P. falciparum* malaria increased significantly in 2004–05 (Figure 32), and this increase was most probably associated with the arrival of refugees from Sub-Saharan Africa, particularly children.[29]

Figure 31. Trends in malaria notifications, by infecting species and year of onset

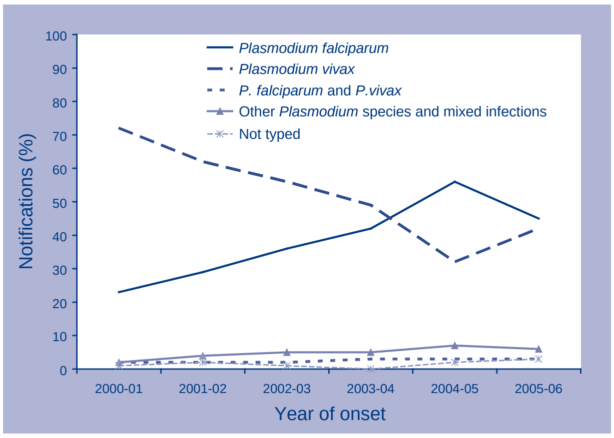
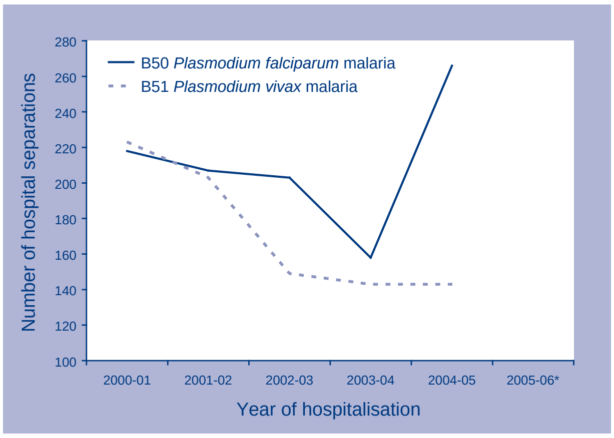
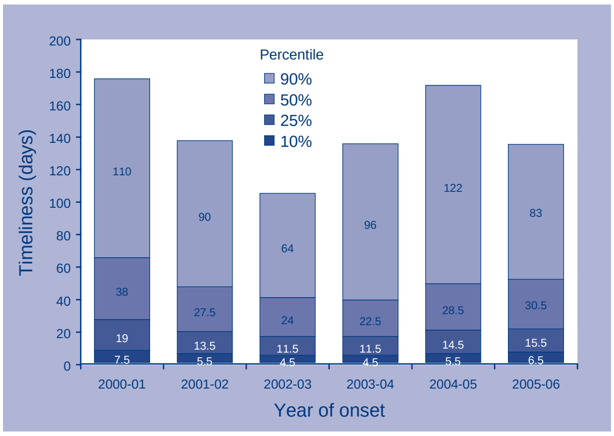


Figure 32. Hospital separations, by principal diagnosis and year of hospitalisation



The timeliness of malaria notifications is shown in Figure 33. In 2005–06, it took 6.5 days for 10 per cent of notifications to reach public health units. The timeliness of malaria notifications was generally better in 2002–03 and 2003–04 for all percentiles.

Figure 33. Timeliness of malaria notifications, Australia, 1 July 2000 to 30 June 2006, by percentile



* Data from 2005-06 not available at time of writing.

Source: Australian Institute of Health and Welfare National Hospital Morbidity Database.

Acknowledgements

The National Arbovirus and Malaria Advisory Committee members are (in alphabetical order): Bart Currie, Peter Daniels, Rogan Lee, Mike Lindsay, Conan Liu, John Mackenzie, Moira McKinnon, Rodney Moran, Aileen Plant, Scott Ritchie, Richard Russell, David Smith, Greg Smith, David Strain, James Walker, Peter Whelan and Phil Wright (Secretariat).

We would also like to thank:

Alison Milton and Maelyn Koo, Office of Health Protection, Australian Government Department of Health and Ageing

Craig Davis, Communicable Diseases Unit, Queensland Health

Craig Williams, Sansom Institute, University of South Australia

Donna Mak, Western Australian Department of Health

Jane Raupach, Department of Health, South Australia

Stephen Doggett, Department of Medical Entomology, ICPMR

The Mosquito-Borne Disease Control Branch (Western Australian Department of Health) and technical staff in the Arbovirus Surveillance and Research Laboratory.

Sentinel reports were provided by:

Linda Hueston, Arbovirus Laboratory, ICPMR

Nina Kurucz, Northern Territory Department of Health and Community Services

Rod Moran, Victorian Department of Human Services

Scott Ritchie, Tropical Public Health Unit, Queensland Health

Tim Kerlin and Jonathan Lee, Northern Australia Quarantine Strategy, AQIS

References

1. Russell RC. Ross River virus: ecology and distribution. *Annu Rev Entomol* 2002;47:1–31.

2. Russell RC, Dwyer DE. Arboviruses associated with human disease in Australia. *Microbes Infect* 2000;2:1693–1704.

3. Hanna JN, Ritchie SA, Merritt AD, van den Hurk AF, Phillips DA, Serafin IL, *et al.* Two contiguous outbreaks of dengue type 2 in north Queensland. *Med J Aust* 1998;168:221–225.

4. Hanna JN, Ritchie SA, Phillips DA, Serafin IL, Hills SL, van den Hurk AF, *et al.* An epidemic of dengue 3 in Far North Queensland, 1997–1999. *Med J Aust* 2001;174:178–182.

5. Hanna JN, Ritchie SA, Hills SL, Pyke AT, Montgomery BL, Richards AR, *et al.* Dengue in north Queensland, 2002. *Commun Dis Intell* 2003;27:384–389.

6. Hanna JN, Ritchie SA, Richards AR, Taylor CT, Pyke AT, Montgomery BL, *et al.* Multiple outbreaks of dengue serotype 2 in north Queensland, 2003/04. *Aust N Z J Public Health* 2006;30:220–225.

7. Mackenzie JS. Emerging zoonotic encephalitis viruses: lessons from Southeast Asia and Oceania. *J Neurovirol* 2005;11:434–440.

8. Hanna JN, Ritchie SA, Phillips DA, Shield J, Bailey MC, Mackenzie JS, *et al.* An outbreak of Japanese encephalitis in the Torres Strait, Australia, 1995. *Med J Aust* 1996;165:256–260.

9. Mackenzie JS, Broom AK, Hall RA, Johansen CA, Lindsay MD, Phillips DA, *et al.* Arboviruses in the Australian region, 1990 to 1998. *Commun Dis Intell* 1998;22:93–100.

10. Hanna JN, Ritchie SA, Phillips DA, Lee JM, Hills SL, van den Hurk AF, *et al.* Japanese encephalitis in north Queensland, Australia, 1998. *Med J Aust* 1999;170:533–536.

11. Johansen CA, van den Hurk AF, Pyke AT, Zborowski P, Phillips DA, Mackenzie JS, *et al.* Entomological investigations of an outbreak of Japanese encephalitis virus in the Torres Strait, Australia, in 1998. *J Med Entomol* 2001;38:581–588.

12. Van Den Hurk AF, Johansen CA, Zborowski P, Phillips DA, Pyke AT, Mackenzie JS, *et al.* Flaviviruses isolated from mosquitoes collected during the first recorded outbreak of Japanese encephalitis virus on Cape York Peninsula, Australia. *Am J Trop Med Hyg* 2001;64:125–130.

13. Brown A, Bolisetty S, Whelan P, Smith D, Wheaton G. Reappearance of human cases due to Murray Valley encephalitis virus and Kunjin virus in central Australia after an absence of 26 years. *Commun Dis Intell* 2002;26:39–44.

14. Büchen-Osmond C. Index to Classification and Taxonomy of Viruses Database, version 3, based on the 7th ICTV Report and subsequent up-dates. 2001 onwards. National Center for Biotechnology Information, National Library of Medicine, National Institutes of Health. Available from: http://www.ncbi.nlm.nih.gov/ICTVdb/index.htm Accessed on June 2005.

15. Bakonyi T, Ivanics E, Erdelyi K, Ursu K, Ferenczi E, Weissenbock H, *et al.* Lineage 1 and 2 strains of encephalitic West Nile virus, central Europe. *Emerg Infect Dis* 2006;12:618–623.

16. World Health Organization. Synopsis of the world malaria situation in 1981. *Wkly Epidemiol Rec* 1983;58:197–199.

17. Musgrave IA. Malarial outbreak in Queensland. *Med J Aust* 1987;146:278.

18. Hanna JN, Ritchie SA, Eisen DP, Cooper RD, Brookes DL, Montgomery BL. An outbreak of *Plasmodium vivax* malaria in Far North Queensland, 2002. *Med J Aust* 2004;180:24–28.

19. Brookes DL, Ritchie SA, van den Hurk AF, Fielding JR, Loewenthal MR. *Plasmodium vivax* malaria acquired in Far North Queensland. *Med J Aust* 1997;166:82–83.

20. Jenkin GA, Ritchie SA, Hanna JN, Brown GV. Airport malaria in Cairns. *Med J Aust* 1997;166:307–308.

21. Merritt A, Ewald D, van den Hurk AF, Stephen S, Jr., Langrell J. Malaria acquired in the Torres Strait. *Commun Dis Intell* 1998;22:1–2.

22. Stickland JF, Roberts AN, Williams V. Transfusion-induced malaria in Victoria. *Med J Aust* 1992;157:499–500.

23. National Hospital Morbidity Database. 1998–99 – 2004–05. Australian Institute of Health and Welfare. Available from: www.aihw.gov.au Accessed on 8 August 2006.

24. Doggett S, Clancy J, Haniotis J, Russell RC, Hueston L, Marchetti M, *et al.* The New South Wales Arbovirus Surveillance and Mosquito Monitoring Program Annual Report 2005–2006: Department of Medical Entomology, Institute of Clinical Pathology and Medical Research, Westmead Hospital; 2006.

25. Chikungunya fever diagnosed among international travellers—United States, 2005–2006. *MMWR Morb Mortal Wkly Rep* 2006;55:1040–1042.

26. Broom AK, Azuolas J, Hueston L, Mackenzie JS, Melville L, Smith DW, *et al.* Australian encephalitis: Sentinel Chicken Surveillance Programme. *Commun Dis Intell* 2001;25:157–160.

27. Broom AK, Lindsay MD, Harrington SA, Smith DW. Investigation of the southern limits of Murray Valley encephalitis activity in Western Australia during the 2000 wet season. *Vector Borne Zoonotic Dis* 2002;2:87–95.

28. Van Den Hurk AF, Montgomery BL, Northill JA, Smith IL, Zborowski P, Ritchie SA, *et al.* Short report: the first isolation of Japanese encephalitis virus from mosquitoes collected from mainland Australia. *Am J Trop Med Hyg* 2006;75:21–25.

29. Liu C, Broom AK, Kurucz N, Whelan PI. Communicable Diseases Network Australia: National Arbovirus and Malaria Advisory Committee annual report 2004–05. *Commun Dis Intell* 2005;29:341–357.