Wildlife Health Australia

Ross River virus in Australian wildlife

Fact sheet

Introductory statement

Ross River virus (RRV) is Australia's most common mosquito-borne infection and is capable of causing severe polyarthritis, fever, myalgia and rash in human cases of clinical disease. Most cases, however, are sub-clinical in both man and animals. The arbovirus is maintained in the environment by transmission between several different vector mosquito species and susceptible vertebrate hosts, most likely marsupials.

Aetiology

RRV is classified as an **arbo**virus as transmission between vertebrate hosts is **ar**thropod **bo**rne. RRV is an RNA virus classified within the Family Togaviridae and the genus Alphavirus. Clinical manifestation of infection with this virus is termed epidemic polyarthritis or Ross River fever or most recently, Ross River virus disease.

Natural hosts

Wildlife hosts of RRV remain largely unconfirmed due to a lack of definitive evidence. Limited experimental infection studies together with serological evidence suggest that marsupials are better amplifiers of RRV than placental mammals, which are in turn better amplifiers than birds (Harley et al. 2001; Kay and Aaskov, 1989; Kay et al. 1986; Marshall and Miles, 1984). Macropods are suspected of playing a significant role as reservoir hosts of the virus (Harley et al. 2001; Kay et al. 1986; Potter et al. 2014). Possums and horses are likely involved in transmission in the urban environment but further investigations are required to confirm this (Boyd et al. 2001; Kay et al. 2007). Bats have also been implicated but limited infection studies suggest they are not likely to play a significant role in maintenance of the virus (Kay et al. 2007; Ryan et al. 1997). There is evidence that humans may also act as amplifying hosts in some situations.

World distribution

RRV is endemic to Australia, Papua New Guinea and the Solomon Islands (Harley et al. 2001). Sporadic epidemics have occurred in Fiji, New Caledonia, American Samoa, and the Cook Islands (Marshall and Miles, 1984). Isolated cases have been reported in India.

Occurrences in Australia

RRV is the most widespread mosquito-borne disease in Australia. RRV occurs throughout Australia, but the incidence of RRV disease is generally highest in the north of the country (Harley et al. 2001) in some coastal regions and along some river systems. This coincides with increased vector mosquito populations, relating to environmental factors such as temperature, humidity, rainfall, and tidal fluctuations. Whilst serological evidence suggests that natural infections occur over a broad geographic range in Australian wildlife species (Table 1), there have been no reports of naturally acquired infections causing clinical disease in these animals.

Epidemiology

RRV is maintained within the environment through transmission between female mosquito vectors and a vertebrate host. Vertical transmission of the virus between infected female mosquitoes and their offspring is also possible. Vectors ingest a viraemic blood meal and the virus amplifies inside the vector, the virus is then transferred from the mosquito to a susceptible vertebrate host via saliva secreted by the mosquito during feeding. Within Australia, *Ochlerotatus camptorhynchus* (previously *Aedes camptorhynchus*), *Ochlerotatus vigilax* (previously *Aedes vigilax*), and *Culex annulirostris* are the three main RRV vectors (Russell, 2002), however RRV has been isolated from >40 mosquito species, several of which act as competent RRV vectors in laboratory studies. Thus, RRV appears to have adapted well to markedly different environments around Australia, with different mosquito species acting as vectors in different regions. The virus may persist in arid regions in desiccation-resistant eggs of some *Aedes* mosquito species. Such vertical transmission of the virus may account for the occurrence of human cases soon after rain in arid regions (Lindsay et al. 1993).

Isolating RRV is complicated by the short viraemic period and lack of clinical signs. To date, there have only been 8 isolates of RRV obtained from non-human vertebrate hosts; these include three from horses, two from Agile Wallabies (*Macropus agilis*) and three from birds: masked finch (*Poephila personata*), brown flycatcher (*Microeca leucophaea*), and magpie lark (*Grallina cyanoleuca*; Azuolas et al. 2003; Doherty et al. 1971; Harley et al. 2001; Pascoe et al. 1978; Whitehead et al. 1968). More extensive data is available on antibody prevalence in Australian wildlife (see Table 1). Outside of Australia, RRV antibodies have been detected in rats, cats, pigs, dogs, domestic fowl, and Banded Rail (*Gallirallus philippensis*) on Tutuila Island, American Samoa (Tesh et al. 1981), cows, pigs and dogs on Rarotonga Island, Cook Islands (Rosen et al. 1981), and an Australasian Gannet (*Morus serrator*) from the North Island of New Zealand (Tompkins et al. 2013).

Table 1. Antibody prevalence for Ross River virus in wild, domestic, and feral animals in Australia.

* = domestic or feral animal, ‡ = captive animal, HI = haemagglutination inhibition test, N = serum neutralization test, E = enzyme-linked immunosorbent assay, Unk = Unknown.

Species	Sampling year	State	% positive (# sampled)	Reference
Placental mammals				
Common water rat (*Hydromys chrysogaster*)	1967-1969	Qld	12 (26)^{HI}	Doherty et al. (1971)
	1967-1969	Qld	100 (1)^{N}	Doherty et al. (1971)
	1985-1990	Vic	100 (1)^{N}	(Aldred et al. 1991)
House mouse (*Mus musculus*)*	1968-1971	NSW	0 (4)^{HI}	(Gard et al. 1973)

	1982-1988	NSW	0 (7)[N]	(Vale et al. 1991)
Smoky mouse (*Pseudomys fumeus*)	1972	NSW	0 (1)[HI]	(Marshall et al. 1980)
New Holland mouse (*Pseudomys novaehollandiae*)	1968-1971	NSW	25 (72)[HI]	(Gard et al. 1973)
Flying-fox (*Pteropus* spp.)	1958-1959	Qld	0 (7)[HI]	Doherty et al. (1966)
	1958-1959	Qld	0 (8)[N]	Doherty et al. (1966)
Flying-fox (*Pteropus alecto & P. poliocephalus*)	1997-1998	Qld	13(165)[N]	(Kay et al. 2007)
Black flying-fox (*Pteropus alecto*)	1967-1969	Qld	50 (6)[HI]	Doherty et al. (1971)
	1967-1969	Qld	100 (3)[N]	Doherty et al. (1971)
Grey-headed flying-fox (*Pteropus poliocephalus*)	1968-1971	NSW	25 (261)[HI]	(Gard et al. 1973)
Little red flying-fox (*Pteropus scapulatus*)	1968-1971	NSW	5 (21)[HI]	(Gard et al. 1973)
	1967-1969	Qld	0 (21)[HI]	Doherty et al. (1971)
	1967-1969	Qld	0 (1)[N]	Doherty et al. (1971)
Rats (mixed introduced & native species)*	1958-1962	Qld	2 (150)[HI]	(Doherty et al. 1966)
	1958-1962	Qld	0 (71)[N]	Doherty et al. (1966)
Bush rat (*Rattus fuscipes*)	1982-1988	NSW	0 (124)[N]	(Vale et al. 1991)
	1972	NSW	0 (7)[HI]	(Marshall et al. 1980)
Australian swamp rat (*Rattus lutreolus*)	1968-1971	NSW	9 (11)[HI]	(Gard et al. 1973)
	1982-1988	NSW	0 (72)[N]	(Vale et al. 1991)
	1985-1990	Vic	19 (21)[N]	(Aldred et al. 1991)
Brown rat (*Rattus norvegicus*)*	1968-1971	NSW	0 (1)[HI]	(Gard et al. 1973)
House rat (*Rattus rattus*)*	1968-1971	NSW	0 (18)[HI]	(Gard et al. 1973)
	1972	NSW	0 (3)[HI]	(Marshall et al. 1980)
Canefield rat (*Rattus sordidus*)	1967-1969	Qld	7 (14)[HI]	Doherty et al. (1971)
Indian hog deer (*Axis porcinus*)	1985-1990	Vic	18 (22)[N]	(Aldred et al. 1991)
Cow (*Bos taurus*)*	1980	NSW	20 (40)[N]	(Cloonan et al. 1982)
	1982-1988	NSW	19 (187)[N]	(Vale et al. 1991)
	1958-1961	Qld	54 (41)[HI]	Doherty et al. (1966)
	1958-1961	Qld	62 (21)[N]	(Doherty et al. 1966)
	<1986	Tas	6 (102)[HI]	(McManus and Marshall, 1986)
	1967-1969	Qld	67 (66)[HI]	Doherty et al. (1971)
	1967-1969	Qld	100 (21)[N]	Doherty et al. (1971)
Dog (*Canis lupus familiaris*)*	1956-1960	Qld	8 (24)[HI]	Doherty et al. (1966)
	1956-1960	Qld	11 (36)[N]	Doherty et al. (1966)
	1967-1969	Qld	53 (30)[HI]	Doherty et al. (1971)
	1967-1969	Qld	40 (5)[N]	Doherty et al. (1971)
	1999	Qld	23 (481)[N]	(Kay et al. 2007)
Goat (*Capra aegagrus hircus*)*	1958	Qld	0 (8)[HI]	Doherty et al. (1966)
	1958	Qld	38 (8)[N]	Doherty et al. (1966)
	1982-1988	NSW	17 (6)[N]	(Vale et al. 1991)
	<1995	NSW	0 (2)[N]	(van Buynder et al. 1995)

Horse (*Equus caballus*)*	1980	NSW	65 (23)[N]	(Cloonan et al. 1982)
	1982-1988	NSW	62 (120)[N]	(Vale et al. 1991)
	1955-1960	Qld	86 (36)[HI]	Doherty et al. (1966)
	1955-1960	Qld	89 (37)[N]	Doherty et al. (1966)
	1995-1996	Vic	60 (1,300)[E]	(Azuolas, 1997)
	1999	Qld	26(379)[N]	(Kay et al. 2007)
	2000-2002	Vic	56 (750)[E]	(Azuolas et al. 2003)
Cat (*Felis catus*)	1999	Qld	11 (579)[N]	(Kay et al. 2007)
Feral pig (*Sus scrofa*)*	1967-1969	Qld	50 (4)[HI]	Doherty et al. (1971)
	1967-1969	Qld	100 (2)[N]	Doherty et al. (1971)
	1985-1990	Vic	33 (15)[N]	(Aldred et al. 1991)
European rabbit (*Oryctolagus cuniculus*)*	1972	NSW	0 (1)[HI]	(Marshall et al. 1980)
Sheep (*Ovis aries*)*	1958-1960	Qld	11 (36)[HI]	Doherty et al. (1966)
	1958-1960	Qld	24 (17)[N]	Doherty et al. (1966)
	1982-1988	NSW	0 (4)[N]	(Vale et al. 1991)
Red fox (*Vulpes vulpes*)	1985-1990	Vic	75 (4)[N]	(Aldred et al. 1991)
Marsupials				
Dasyuridae				
Brown antechinus (*Antechinus stuartii*)	1972	NSW	0 (15)[HI]	(Marshall et al. 1980)
Western quoll (Dasyurus geoffroii)	<1995	WA	1 (1)[Unk.]	(Lindsay, 1995)
Tasmanian devil (*Sarcophilus harrisii*)	<1986	Tas	100 (4)[HI]	(McManus and Marshall, 1986)
White-footed dunnart (*Sminthopsis leucopus*)	1982-1988	NSW	0 (3)	(Vale et al. 1991)
Diprotodontia				
Southern hairy-nosed Wombat (*Lasiorhinus latifrons*)	1999-2004	NSW[‡]	0 (2)[E]	(Old and Deane, 2005)
Sugar glider (*Petaurus breviceps*)	1968-1971	NSW	50 (2)[HI]	(Gard et al. 1973)
Koala (*Phascolarctos cinereus*)	1985-1990	Vic	16 (93)[N]	(Russell, 1995)
	1999-2004	NSW[‡]	0 (12)[E]	(Old and Deane, 2005)
Common ringtail possum (*Pseudocheirus peregrinus*)	<1986	Tas	0 (1)[HI]	(McManus and Marshall, 1986)
	1968-1971	NSW	66 (3)[HI]	(Gard et al. 1973)
Common brushtail possum (*Trichosurus vulpecula*)	1967-1969	Qld	50 (2)[HI]	Doherty et al. (1971)
	1968-1971	NSW	100 (1)[HI]	(Gard et al. 1973)
	<1986	Tas	77 (13)[HI]	(McManus and Marshall, 1986)
	1985-1990	Vic	1 (1)[N]	(Aldred et al. 1991)
	<1997	Unk.	4 (243)[N]	(Azuolas, 1997)
	1998-1999	Qld	18(100)[N]	(Kay et al. 2007)
	2005	NSW	0 (72)[E]	(Hill et al. 2009)
Common wombat (*Vombatus ursinus*)	<1986	Tas	43 (7)[HI]	(McManus and Marshall, 1986)

Peramelemorphia				
Northern brown bandicoot (*Isoodon macrourus*)	1958-1963	Qld	1 (64)[HI]	Doherty et al. (1966)
	1958-1963	Qld	50 (2)[N]	Doherty et al. (1966)
Southern brown bandicoot (*Isoodon obesulus*)	1982-1988	NSW	25 (4)[N]	(Vale et al. 1991)
	<1986	Tas	100 (7)[HI]	(McManus and Marshall, 1986)
Bilby (*Macrotis lagotis*)	1958	Qld	0 (1)[HI]	(Doherty et al. 1966)
Eastern barred bandicoot (*Perameles gunnii*)	<1986	Tas	100 (2)[HI]	(McManus and Marshall, 1986)
Long-nosed bandicoot (*Perameles nasuta*)	1958-1963	Qld	0 (40)[HI]	Doherty et al. (1966)
	1982-1988	NSW	25 (8)[N]	(Vale et al. 1991)
Macropodiformes				
Tasmanian bettong (*Bettongia gaimardi*)	<1986	Tas	100 (1)[HI]	(McManus and Marshall, 1986)
Woylie (*Bettongia penicillata ogilbyi*)	2006-2008	WA	0 (73)[E]	(Pacioni et al. 2014)
Agile wallaby (*Macropus agilis*)	1967-1969	Qld	85 (169)[HI]	Doherty et al. (1971)
	1967-1969	Qld	19 (12)[N]	Doherty et al. (1971)
Black-striped Wallaby (*Macropus dorsalis*)	1960	Qld	27 (11)[HI]	Doherty et al. (1966)
	1960	Qld	100 (1)[N]	Doherty et al. (1966)
Tammar wallaby (*Macropus eugenii*)	2001-2004	NSW[‡]	15 (224)[E]	(Old and Deane, 2005)
Western grey kangaroo (*Macropus fuliginosus*)	2006-2009	WA	44 (2632)[N]	(Potter et al. 2014)
	<1995	WA	35 (Unk.)[Unk.]	Lindsey et al. 1995
Eastern grey kangaroo (*Macropus giganteus*)	1958-1960	Qld	59 (37)[HI]	Doherty et al. (1966)
	1958-1960	Qld	100 (14)[N]	Doherty et al. (1966)
	<1995	NSW	50 (2)[N]	(van Buynder et al. 1995)
	1982-1988	NSW	50 (30)[N]	(Vale et al. 1991)
	<1986	Tas	40 (10)[HI]	(McManus and Marshall, 1986)
	1967-1969	Qld	89 (28)[HI]	Doherty et al. (1971)
	1967-1969	Qld	100 (5)[N]	Doherty et al. (1971)
	1989	Vic	36 (39)[N]	(Aldred et al. 1991)
Parma wallaby (*Macropus parma*)	1999-2004	NSW[‡]	0 (5)[E]	(Old and Deane, 2005)
Whiptail wallaby (*Macropus parryi*)	1960	Qld	66 (3)[HI]	Doherty et al. (1966)
	1960	Qld	100 (1)[N]	Doherty et al. (1966)
Wallaroo (*Macropus robustus*)	1999-2004	NSW[‡]	36 (11)[E]	(Old and Deane, 2005)
Red-necked Wallaby (*Macropus rufogriseus*)	1960	Qld	67 (21)[HI]	Doherty et al. (1966)
	1960	Qld	100 (5)[N]	Doherty et al. (1966)
	<1986	Tas	67 (33)[HI]	(McManus and Marshall, 1986)

	1982-1988	NSW	86 (7)[N]	(Vale et al. 1991)
Red kangaroo (*Macropus rufus*)	1958	Qld	52 (25)[HI]	Doherty et al. (1966)
	1958	Qld	100 (10)[N]	Doherty et al. (1966)
	<1995	NSW	0 (20)[N]	(van Buynder et al. 1995)
Northern nailtail wallaby (*Onychogalea unguifera*)	1967-1969	Qld	100 (1)[HI]	Doherty et al. (1971)
Potoroo (*Potorous tridactylus*)	<1986	Tas	100 (2)[HI]	(McManus and Marshall, 1986)
Quokka (*Setonix brachyurus*)	<1995	WA	100 (4)[Unk.]	(Lindsay, 1995)
Tasmanian pademelon (*Thylogale billardierii*)	<1986	Tas	56 (50)[HI]	(McManus and Marshall, 1986)
Red-necked pademelon (*Thylogale thetis*)	1960	Qld	0 (3)[HI]	Doherty et al. (1966)
Swamp wallaby (*Wallabia bicolor*)	1982-1988	NSW	83 (6)[N]	(Vale et al. 1991)
Monotremes				
Short-beaked echidna (*Tachyglossus aculeatus*)	1982-1988	NSW	0 (6)[N]	(Vale et al. 1991)
Birds				
Birds (mixed native species)	1957-1964	Qld	1 (145)[HI]	Doherty et al. (1966)
	1957-1964	Qld	6 (16)[N]	Doherty et al. (1966)
	1967-1969	Qld	50 (48)[HI]	Doherty et al. (1971)
	1967-1969	Qld	63 (8)[N]	Doherty et al. (1971)
Tawny frogmouth (Podargus strigoides)	1968-1971	NSW	17 (6)[HI]	(Gard et al. 1973)
Azure kingfisher (*Ceyx azurea*)	1968-1971	NSW	0 (1)[HI]	(Gard et al. 1973)
Australian raven (*Corvus coronoides*)	1968-1971	NSW	0 (1)[HI]	(Gard et al. 1973)
Laughing kookaburra (*Dacelo novaeguineae*)	1968-1971	NSW	0 (1)[HI]	(Gard et al. 1973)
Yellow-faced honeyeater (*Lichenostomus chrysops*)	1968-1971	NSW	0 (4)[HI]	(Gard et al. 1973)
Domestic fowl (*Gallus gallus domesticus*)*	1963-1966	Qld	9 (147)[HI]	(Doherty et al. 1968)
Reptiles				
Unidentified	1967-1969	Qld	0 (15)[HI]	(Doherty et al. 1971)

Experimental infection studies on Australian wildlife species indicate that RRV has a relatively short incubation period, not exceeding six days (see Table 5 in Harley et al. 2001). Experimental infections resulted in viraemia in the following Australian wild and domestic species: house mouse (*Mus musculus*), New Holland mouse (*Pseudomys novaehollandiae*), house rat (*Rattus rattus*), brown rat (*Rattus norvegicus*), grey-headed flying-fox (*Pteropus poliocephalus*), European rabbit (*Oryctolagus cuniculus*), horse (*Equus caballus*), sheep (*Ovis aries*), pig (*Sus scrofa*), northern brown bandicoot (*Isoodon macrourus*), *Antechinus* sp., Tammar wallaby (*Macropus eugenii*), agile wallaby (*Macropus agilis*), eastern grey kangaroo (*Macropus giganteus*), domestic fowl (*Gallus gallus domesticus*), Pacific black duck (*Anas superciliosa*) and little corella (*Cacatua sanguinea*). Of the aforementioned species, the highest viraemia titres were recorded in *P. novaehollandiae* (7.6 PFU/ml) and

R. norvegicus (7.4 PFU/ml). Mortality and morbidity rates remain largely unknown. It is generally considered that kangaroos remain clinically unaffected by the virus. In one experimental infection study, three of ten common brushtail possums developed a high viraemia, each exhibiting clinical signs (Boyd et al. 2001). Of these three, one died, one was euthanased due to the severity of the symptoms, and one recovered. In addition, RRV has been implicated in some cases of musculoskeletal disease in horses (Azuolas et al. 2003; El-Hage et al. 2008).

Clinical signs

Known clinical signs in animals are limited to three species:

Common brushtail possums:

Possums infected experimentally with RRV exhibited the following clinical signs: wobbly gait, lethargy, loss of appetite and in some cases, death (Boyd et al. 2001).

Mice:

Experimental infection with specific strains of RRV caused death in young (<10 days old) laboratory mice (*Mus musculus*) and weight loss, impaired growth, ruffled fur and severe degradation of hind limb muscle leading to hind limb dragging in older mice (Lidbury et al. 2000; Morrison et al. 2006).

Horses:

RRV infection is nonfatal in horses and is primarily asymptomatic (Azuolas, 1998; Azuolas et al. 2003; El-Hage et al. 2008; Gard et al. 1977; Kay et al. 1987). However, RRV has been implicated in cases of musculoskeletal disease in performance horses (Azuolas et al. 2003; El-Hage et al. 2008). RRV has been isolated from horses exhibiting clinical signs such as lethargy, loss of appetite, depression, lameness, stiffness, swollen joints, distal limb swelling, ataxia, pyrexia, serous nasal discharge, submaxillary lymphadenopathy, petechial haemorrhages on the gingival mucous membranes and mild colic (Azuolas et al. 2003; El-Hage et al. 2008). Some clinical signs, such as limb soreness and poor performance, can be ongoing (El-Hage et al. 2008).

Diagnosis

RRV-specific antibodies can be detected using neutralisation and haemagglutination inhibition (HI) assays or an epitope-blocking ELISA. The neutralisation assay is considered to be the gold standard, with demonstration of a greater than four-fold rise in RRV-specific antibody titre between acute and convalescent serum samples required for definitive diagnosis. Antibodies in humans and horses often remain high for several years. Therefore, it is prudent to demonstrate a rising titre in animals when aiming to demonstrate recent infection. Virus isolation is achieved through culture in C6/36 cells or inoculation of mice with serum supernatant.

Clinical pathology

Wildlife species infected with RRV are likely to mount an immune response. Antibodies capable of virus neutralisation and haemagglutination inhibition are likely produced. We are not aware of any data relating to clinical pathology in Australia wildlife infected with RRV. Fibrinogen may be elevated in infected horses (El-Hage et al. 2008).

Pathology

Pathology associated with infection in wildlife species has only been described in three Common Brushtail Possums exhibiting clinical signs (Boyd et al. 2001). The brain was soft, with haemorrhagic and oedematous meninges and petechial haemorrhages of the occipital lobe. Mild congestion of the liver and blood filled pulmonary alveolar spaces were also present. Animals were in good body condition. No histological changes have been described in wildlife. The majority of wildlife species capable of mounting an immune response or becoming viraemic are considered to be asymptomatic, hence no further pathological changes have been reported. Experimental infection with RRV in laboratory mice resulted in inflammation of hind limb bones, joints, and skeletal muscle and degradation of hind limb skeletal muscle (Lidbury et al. 2000; Morrison et al. 2006).

Differential diagnoses

As the majority of wildlife species exhibit no clinical signs of infection, differential diagnoses have not been described. In possums exhibiting clinical signs, differential diagnoses include other types of neurological disease. RRV and other arboviruses such as Barmah Forest virus should be considered in cases of unexplained neuromuscular disease, neurological disease and death.

Laboratory diagnostic specimens

Serum is required for most diagnostic tests. Whole blood should be collected from the animal in tubes suitable for serum separation. The neutralisation assay requires a minimum of 20 µL of serum. If repeats are necessary, a further 20 µL may be required.

Laboratory procedures

Briefly, this involves the addition of virus stock and cells to a 96-well tissue culture plate containing serially diluted serum. After five days of incubation, wells are examined microscopically for cytopathic effect (CPE). In the event that neutralising antibodies are present, they bind (neutralise) to the virus and prevent cells from undergoing CPE. Neutralisation titres are expressed as the reciprocal of the highest serum dilution where CPE does not occur. Neutralisation titres of =40 are considered to be positive (Johansen et al. 2005b).

Haemagglutination inhibition assays are carried out according to Clarke and Casals (1958). The epitope-blocking ELISA is not used as commonly for the diagnosis of RRV in vertebrates, a likely result of having only been developed in recent years (Oliveira et al. 2006). It does however offer a number of advantages over the other two assays, being less time consuming than neutralisation and less tedious in the preparation of serum, antigen and erythrocytes than haemagglutination inhibition.

Treatment

Treatment for RRV is supportive and symptomatic only and is not required in wildlife due to an absence of clinical signs. In horses the use of analgesics, antipyretics and non-steroidal anti-inflammatory drugs can aid in treating symptoms such as muscle soreness, stiffness, and joint swelling.

Prevention and control

RRV is transmitted by a mosquito vector, therefore mosquito control is the most effective method of minimising viral activity. Local government authorities around Australia are responsible for undertaking mosquito management programs using an integrated approach. This includes monitoring mosquito populations, generating warnings when viral activity has increased, and implementing a range of cultural, physical and chemical control methods to reduce mosquito numbers. To avoid being bitten by mosquitoes, people should use repellent, wear long sleeved clothing and remain indoors as much as possible at dusk and dawn. There is no vaccine for RRV.

Surveillance and management

Human RRV disease is monitored under the National Notifiable Diseases Surveillance System (NNDSS) whereby all confirmed cases must be reported. Whilst each state collates their own case data, results are reported to the Australian Government Department of Health. Animal Health Australia runs a National Arbovirus Monitoring Program whereby mosquito vectors are monitored in all Australian states and territories to calculate the relative abundances of a range of arbovirus vector species as well as viral activity (see http://www.animalhealthaustralia.com.au/programs/disease-surveillance/national-arbovirus-monitoring-program/). Combining climatic data with mosquito surveillance data can assist in accurately predicting impending viral activity and providing forewarning to the public (Woodruff et al. 2006).

There is no AUSVETPLAN or Import Risk Analysis for RRV.

Statistics

Wildlife disease surveillance in Australia is coordinated by Wildlife Health Australia. The National Wildlife Health Information System (eWHIS) captures information from a variety of sources including Australian government agencies, zoo and wildlife parks, wildlife carers, universities and members of the public. Coordinators in each of Australia's States and Territories report monthly on significant wildlife cases identified in their jurisdictions. NOTE: access to information contained within the National Wildlife Health Information System dataset is by application. Please contact admin@wildlifehealthaustralia.com.au.

Research

Wildlife species are suspected of playing a significant role in the maintenance and amplification of RRV yet definitive evidence pinpointing reservoir host species is lacking. Not all vertebrate species capable of mounting an immune response to infection are competent viral hosts. Similarly, species capable of becoming viraemic in experimental infection studies are not necessarily significant hosts in the natural environment. Serological evidence, together with limited experimental infection studies, suggests that macropods, Common Brushtail Possums, horses, and potentially bats, are a likely reservoir host of the virus in Australia. Major epidemics in human populations in the southwest of WA occur in a 3-4 year cycle, despite mosquito populations and environmental conditions favouring RRV activity in the years in between outbreaks (Johansen et al. 2005a; Lindsay et al. 2005; Lindsay et al. 1996). It is hypothesized that herd (mob) immunity within the vertebrate host population is responsible for this phenomenon. Further experimental infection studies are required to confirm local reservoir hosts.

Human health implications

RRV is the most common mosquito-borne infection in Australia with approximately 5,000 human cases reported annually (Russell, 2002). There is a recent Australian case of a human becoming infected with RRV after receiving an infected blood transfusion (Hoad et al. 2015), this is the first instance of RRV being transferred in this manner. The incubation period is usually 7-9 days but can vary from 3 to 21 days (Harley et al. 2001). Some cases may be asymptomatic but others develop into clinical disease characterised by polyarthritis, rash, myalgia, headache, fatigue and fever. Symptoms often persist for approximately four weeks but in chronic cases symptoms will persist for many months to years (Harley et al. 2001). RRV disease is a notifiable disease so all confirmed cases must be reported.

Conclusions

Ross River Virus is Australia's most common mosquito-borne infection, which can cause severe polyarthritis in symptomatic humans. From serological data and limited experimental infection studies, wildlife species, in particular macropods, have been strongly implicated in this role. In urban environments where these animals are largely absent, it is possible that Common Brushtail Possums, horses, and potentially bats, are involved in viral transmission. Research priorities include further experimental infection and long term serology studies to define the vertebrate host species of RRV and ascertain the nature of the immune response mounted as a result of infection. This information will assist in determining the influence host populations have on viral epidemiology.

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The Australian Government Department of Health has state-specific fact sheets on Australian Arboviruses: http://www.health.gov.au/internet/main/publishing.nsf/Content/health-arbovirus-resources-factsheets.htm

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To provide feedback on this fact sheet

We are interested in hearing from anyone with information on this condition in Australia, including laboratory reports, historical datasets or survey results that could be added to the National Wildlife Health Information System. Negative data are also valuable. If you can help, please contact us at admin@wildlifehealthaustralia.com.au.

Wildlife Health Australia would be very grateful for any feedback on this fact sheet. Please provide detailed comments or suggestions to admin@wildlifehealthaustralia.com.au. We would also like to hear from you if you have a particular area of expertise and would like to produce a fact sheet (or sheets) for the network (or update current sheets). A small amount of funding is available to facilitate this.

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