Japanese encephalitis
Fact sheet

Key points

- Japanese encephalitis (JE) is an acute mosquito-borne viral disease that can cause reproductive losses and encephalitis in susceptible species
- Disease occurs most commonly in pigs and horses but can also affect humans on rare occasions
- Japanese encephalitis virus (JEV) is maintained in nature by transmission cycles involving *Culex* sp., mosquitoes, birds and pigs
- The epidemiology of JEV (wildlife reservoirs) is not fully understood
- Wild birds - particularly of the family Ardeidae (wading birds; herons and egrets) are considered to be reservoirs for JE virus in Asia
- The wildlife reservoirs for JE in the Australia context are not known but are assumed to be similar to overseas i.e. herons and egrets. It is possible that other wildlife species or domestic species (in addition to pigs) may play a role in the epidemiology of the disease .

Introductory statement

Japanese encephalitis (JE) is an acute mosquito-borne viral disease that can cause reproductive losses and encephalitis in susceptible animal species. JE virus (JEV) is maintained in nature by transmission cycles involving mosquitoes with certain species of wild birds and pigs as the vertebrate hosts. Disease occurs most commonly in pigs and horses but can also affect humans on rare occasions. JE is a nationally notifiable disease. JEV has substantially extended its geographic range in recent years and has been detected with some frequency in the Torres Strait and other islands bordering northern Australia. JE is considered a significant threat to Australia because the host species and competent vectors are present, and it has entered Australia on a semi-regular basis.

In February-March 2022, JEV was detected in piggeries in southern Qld, NSW, Victoria and South Australia. Cases in humans were also reported.

Aetiology

Japanese encephalitis virus (JEV); Genus: *Flavivirus;* Family: *Flaviviridae.* There are five genotypes (I-V).

NB: Other notable viruses in this genus include Murray Valley encephalitis, Kunjin, West Nile, Dengue, and St Louis encephalitis viruses.

Grouping (non-taxonomic): Arbovirus (Arthropod borne virus, see separate factsheet on Arboviruses for more details).

Natural hosts

JE virus (JEV) is maintained in nature by transmission cycles involving mosquitoes (primarily *Culex* sp.) with certain species of wild and domestic birds and pigs as the vertebrate hosts.

The primary (reservoir) host of JEV is believed to be wild birds, especially those in the family Ardeidae (herons and egrets) (van den Hurk et al. 2009a).

Domestic pigs are the principle amplifying hosts of JEV, especially in epidemic areas, and may act as maintenance hosts in endemic areas (Mackenzie et al. 2007). Birds may also play a role as amplifying hosts in areas where pigs are not present (van den Hurk et al. 2009a).

JEV can infect a wide range of species although few species develop signs of disease.

Clinically affected hosts include horses, donkeys and humans. These are all considered dead-end hosts as the level of viraemia is too low to allow infection to be transmitted. Less than 5% of human infections develop signs of disease (Hills et al. 2015).

Clinically unaffected hosts include cattle, sheep, goats, dogs, cats, rodents, bats, reptiles and amphibians. These species can become infected with JEV but rarely, or never, show clinical signs of disease. It is not known if other Australian wildlife species can develop clinical disease or act as reservoirs for JEV.

World distribution

JEV occurs in temperate and tropical regions of eastern and southern Asia, in south-east Russia, and sporadically in Papua New Guinea and the Torres Strait islands. The geographic range of JE has expanded considerably in the last four decades. Major epidemics have occurred when the virus spread into new areas, e.g. India in the late 70s.

Occurrences in Australia

JE has been considered exotic to mainland Australia. Until 2022, sporadic cases had been reported in the Torres Strait and one human case from the Tiwi Is in the NT (NT government 2022).

In 1995, three human cases, (two fatal) occurred on Badu Island in the Torres Strait (van den Hurk et al. 2006). In 1998, another case was reported from Badu Island (Australian Department of Health and Ageing 2004). Shortly after, a fisherman contracted JE in the Mitchell River area on the west of Cape York Peninsula (Ritchie and Rochester 2001). This was the first known human case acquired on the Australian mainland. Seroconversion has also been documented in sentinel pigs on Cape York Peninsula (Australian Department of Health and Ageing 2004). In 2004, JEV was isolated from a mosquito on the Cape York Peninsula (Hanna et al. 1996). Strong winds, such as those associated with cyclones, are suspected to be capable of blowing infected mosquitoes from Papua New Guinea into northern Australia (Hanna et al. 1999).

In 2021 a human case was reported from the Tiwi Is in the NT (NT government 2022).

In February-March 2022, after an extremely wet spring and summer, JE was detected and confirmed in piggeries in Vic, southern Qld NSW and SA. JEV had not previously been shown to have established transmission on mainland Australia. Weather conditions (above average rainfall and warmer minimum temperature) may have been contributing factors in this event (Australian government 2022).

Epidemiology

JEV is maintained in nature by transmission cycles involving *Culex* sp. mosquitoes and certain species of wild and domestic birds and pigs as the vertebrate hosts. Wild birds (particularly of the family Ardeidae (wading birds; herons and egrets) are believed to act as reservoir hosts and pigs act as amplifying hosts for JEV (van den Hurk et al. 2006).

JEV is transmitted via the bite of a competent mosquito vector and has been isolated from more than 30 mosquito species. Transmission of the virus via semen from infected boars is also possible (Hanna et al. 1999). It is uncertain if transmission via infected milk is possible (Hanna et al. 1999; van den Hurk et al. 2006).

Certain insectivorous animals (e.g. lizards and bats) may contract the virus after ingesting infected mosquitoes. Horses, humans and ruminants are considered to be dead-end hosts. It is not known if other affected species of Australian native wildlife could act as reservoirs for this virus (Hanna et al. 1999; van den Hurk et al. 2003).

Overseas, transmission generally occurs in agricultural zones, particularly in the vicinity of pig farms and irrigated areas such as rice paddies. *Culex tritaeniorhynchus* is the primary vector of JEV in Asia and thrives in the rice paddies of south-east Asia where wading birds also flourish (Animal Health Australia 2020). Within Australia, *Cx. annulirostris* is considered the likely primary vector, although *Cx. gelidus* and *Cx. palpalis* are also competent vectors (Animal Health Australia 2020). Research on mosquito feeding patterns in northern Australia indicates that marsupials, particularly the agile wallaby (*Macropus agilis*), are preferred to feral pigs and birds by these mosquito species (van den Hurk et al. 2009a). As marsupials are thought to be inefficient hosts for the transmission of JEV, it is possible that the lack of establishment of the virus in Australia was in part due to the known competent vector mosquito species preferring to feed on macropods rather than pigs or birds (Hanna et al. 1999; Animal Health Australia 2020).

Studies have proposed that the main overwintering mechanisms of JEV in Japan might be reintroduction by wild birds and extended incubations in amphibians, reptiles and bats (van den Hurk et al. 2009b).

In the Australian north, the movements of wild birds and local human populations (with possible associated introduction of vectors or pigs) have been considered to pose a risk for introduction of JEV. In addition, feral pigs are considered an abundant and widespread potential wildlife amplifying or reservoir host.

A study showed experimental transmission of JEV from the black flying-fox, *Pteropus alecto*, to *Cx. annulirostris* mosquitoes, despite the absence of detectable viraemia in the host. Infection rates in recipient mosquitoes were low, however the authors suggested that this species might play a role in the dispersal of JEV, because of the high population densities of flying-foxes in roosting camps, coupled with their migratory behaviour (van den Hurk et al. 2009a; Hall-Mendelin et al. 2012).

Incubation period

- Humans: 6-16 days
- Pigs: 1 day
- Horses: 8-10 days
- Herons: 1-2 days (van den Hurk et al. 2009b)

- Bats, reptiles and amphibians: extended incubation possible; experimental studies demonstrated viraemia in bats after 107 days of artificial incubation.

Clinical signs

Humans: Acute signs in humans include sudden onset of fever, gastrointestinal signs and headache Up to 20-50% of clinical cases may develop encephalitis with associated neurological signs. Approximately 30% of survivors are left with ongoing and normally severe sequelae (Hills et al. 2015).

Pigs: Transplacental transmission of JEV can cause foetal encephalitis, abortion and stillbirth, with mummified foetuses. JEV can cause poor fertility in boars. Non-pregnant animals may show no signs. Surviving piglets commonly exhibit tremors, convulsions and death. Encephalitis may occur in piglets up to six months of age (see Animal Health Australia 2020).

Horses: Three clinical syndromes (see Animal Health Australia 2020):

1. Transient syndrome: fever up to 40°C for 2-3 days with anorexia, sluggish movement and congested or jaundiced mucous membranes; followed by an uneventful recovery
2. Lethargic syndrome: the above signs plus fevers reaching 41°C for up to a week, difficulty in swallowing, neck rigidity, radial paralysis, pronounced lethargy and falling or staggering
3. Hyperexcitable syndrome: high fever, aimless wandering or violent demented behaviour, blindness, profuse sweating, trembling, collapse and death.

Diagnosis

In humans and animals, JE is confirmed either by isolation of the virus or by a rising antibody titre (in the absence of recent vaccination). In animals, a serum neutralisation test or immunohistochemistry may also confirm the diagnosis (van den Hurk et al. 2009a).In humans, if the infection is believed to be acquired in Australia, confirmation from a second reference laboratory is required.

Clinical pathology

In humans, clinical laboratory findings of JE include moderate leucocytosis, mild anaemia, hyponatraemia, and cerebrospinal fluid (CSF) pleocytosis with a lymphocytic predominance (Hills et al. 2015; Animal Health Australia 2020).

Pathology

There are no characteristic gross lesions in humans, animals or aborted foetuses. Oedema of the brain may be present in piglets.

In animals: histologically, there may be pronounced necrosis of Purkinje cells in the cerebellum with no inclusion bodies. A diffuse non-suppurative encephalomyelitis with neuronal necrosis, neuronophagia, gliosis, perivascular cuffing, spinal hypomyelinogenesis and engorged blood vessels with many mononuclear cells may be seen. Similar changes may be seen in humans.

Differential diagnoses

Pigs

Diseases which cause abortions in sows and neurological diseases in piglets should be considered as differentials, e.g. Aujeszky's disease, blue eye paramyxovirus, classical swine fever, haemagglutinating encephalomyelitis, Leptospirosis, porcine brucellosis, porcine polioencephalomyelitis (either Talfan or Teschen type), porcine parvovirus, porcine Reproductive and Respiratory Disease, Salmonellosis and salt poisoning (Animal Health Australia 2020).

Horses

Diseases which cause fevers and neurological symptoms or ataxia in horses should be considered as differentials.

Laboratory diagnostic specimens

In animals, diagnosis is made from serum, or from brain and other tissues collected aseptically and less than 12 hours post-mortem from animals in the acute stage of the disease. A range of fixed tissue samples should also be collected. Fresh samples should be transported chilled to the local government diagnostic laboratory, if expected to arrive within 48 hours after collection. Otherwise samples should be frozen and transported on dry ice (Hills et al. 2015).

Laboratory procedures

Virus isolation may be performed in appropriate cell line cultures after mouse inoculation with clinical material. Serological tests used in both animals and humans include complement fixation, haemagglutination inhibition, serum neutralisation and/or enzyme-linked immunosorbent assay. Additional tests used in humans include immunoglobulin detection in serum or CSF, and detection of JEV RNA in clinical material(Animal Health Australia 2020).

Treatment

There is no specific treatment for JEV infection. For horses and humans, symptomatic and supportive treatment will depend on clinical signs.

Prevention and control

In humans, pigs and horses, vaccination is a possible control method but there are limitations and considerations with deployment and supplies (Animal Health Australia 2020). Efforts should be undertaken to prevent mosquito-bites in both animals and humans. Ongoing or targeted mosquito control should also be performed, as appropriate. It has been recommended that piggeries should be located a minimum of 3 km from human dwellings.

Details of domestic animal control during a JE outbreak can be found in the AUSVETPLAN Japanese Encephalitis Response Strategy (Animal Health Australia 2020).

No special precautions are recommended for handling of animal carcasses or pathological specimens as they are not considered a source of infection (Animal Health Australia 2020).

Surveillance and management

The AUSVETPLAN for JE is available at:

www.animalhealthaustralia.com.au/our-publications/ausvetplan-manuals-and-documents.

In Australia, JE is a notifiable disease in both humans and animals. Trace-back activities may be instigated on infected humans and animals, and pigs may be monitored for further viral activity. Serum banking of potential wild animal hosts for later testing may be helpful (Animal Health Australia 2020).

Arbovirus surveillance is conducted in Australia via monitoring of mosquitoes and sentinel chicken flocks.

Statistics

Wildlife disease surveillance in Australia is coordinated by the 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. See the WHA website for more information: www.wildlifehealthaustralia.com.au/ProgramsProjects/eWHISWildlifeHealthInformationSystem.aspx#requests

There are no reports of JE in Australian wildlife in the National Wildlife Health Surveillance Database.

Research

AUSVETPLAN recommends that the National Arbovirus Monitoring Program and flavivirus sentinel programs should monitor the spread of JEV through the use of appropriate sentinel hosts and vector testing and monitoring (Animal Health Australia 2020).

To better understand the role of Australian wildlife in JEV epidemiology, and to better understand the potential impact of JE in Australia, areas of research include:

- Evaluation of Australian wildlife as potential reservoirs or clinically affected species
- Epidemiological modelling of the possible spread of JEV in Australia, based on vector competence, abundance and movement and potential host dynamics (including wild birds and feral pigs)
- Assessment of current biosecurity measures
- Assess the timeliness of likely detection, reporting and control measures
- Analyses of the financial impact of a JE incursion or establishment.

Human health implications

JEV is responsible for more than 60,000 human cases of clinical JE globally each year, with an expected case fatality ratio of around 25% (Campbell et al. 2011). Most infections occur in clusters at the end of the mosquito breeding season or summer (Hanna et al. 1999; Animal Health Australia 2015).

The Australian Department of Health has a fact sheet on Japanese encephalitis, that can be consulted for further information on JE and human health (www.health.gov.au/health-topics/japanese-encephalitis).

Conclusions

In early 2022, JEV was detected in piggeries in southern Qld, NSW, Victoria and South Australia. Cases in humans were also reported. JE is a notifiable disease in Australia. It can cause severe clinical disease in affected species. The range of JEV is expanding globally. It has previously entered the Torres Strait islands and the Australian mainland. The epidemiological cycle JEV is not fully understood but wildlife reservoirs (wild birds) and competent vectors for JEV are both present in Australia. It is not known whether other Australian wildlife such as dingos, marsupials, bats, amphibians and reptiles are susceptible, are potential reservoir hosts, or may play a role in impeding the establishment of JE.

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To provide feedback on this fact sheet

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Find out more at **www.wildlifehealthaustralia.com.au**

Email **admin@wildlifehealthaustralia.com.au**

Or call **+61 2 9960 6333**