

Lyssaviruses

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DISEASE WATCH HOTLINE: 1800 675 888

The Disease Watch Hotline is a toll-free telephone number that connects callers to the relevant state or territory officer to report concerns about any potential emergency disease situation. Anyone suspecting an emergency disease outbreak should use this number to get immediate advice and assistance.

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Gray-headed Flying Fox (*Pteropus poliocephalus*).



1

Introduction

1.1 This manual

1.1.1 Purpose

As part of AUSVETPLAN (the Australian Veterinary Emergency Plan), this response strategy contains the nationally agreed approach for the response to an incident – or suspected incident – of lyssavirus infection in Australia. It has been developed to guide decision making to ensure that a fast, efficient and effective response can be implemented consistently across Australia with minimal delay.

1.1.2 Scope

This response strategy covers infection caused by viruses of the genus *Lyssavirus*, including rabies lyssavirus (which is exotic to Australia), other exotic lyssaviruses, and Australian bat lyssavirus (which is endemic in Australia).

This response strategy provides information about:

- the disease (Section 2)
- the implications for Australia, including potential pathways of introduction, social, environmental, human health and economic effects, and the critical factors for a response to the disease (Section 3)
- the agreed policy and guidelines for agencies and organisations involved in a response to an incident or outbreak (Section 4)
- declared areas and premises classifications (Section 5)
- biosecurity controls, including quarantine and movement controls (Section 6)
- response surveillance and establishing proof of freedom (Section 7).

The key features of lyssaviruses are described in the **Lyssavirus fact sheet** (Appendix 1).

1.1.3 Development

The strategies in this document for the diagnosis and management of an outbreak of lyssavirus are based on risk assessment. They are informed by the recommendations in the World Organisation for Animal Health (OIE) *Terrestrial animal health code* (Chapter 8.14) and the OIE *Manual of diagnostic tests and vaccines for terrestrial animals* (Chapter 3.1.17). The strategies and policy guidelines are for emergency situations and are not applicable to policies for imported animals or animal products.

This manual has been produced in accordance with the procedures described in the **AUSVETPLAN Overview**, and in consultation with Australian national, state and territory governments; the relevant livestock industries; nongovernment agencies; and public health authorities, where relevant.

In this manual, text placed in square brackets [xxx] indicates that that aspect of the manual remains unresolved or is under development; such text is not part of the official manual. The issues will be worked on by experts and relevant text included at a future date.

1.2 Other documentation

This response strategy should be read and implemented in conjunction with:

- other AUSVETPLAN documents, including the operational, enterprise and management manuals; and any relevant guidance and resource documents. The complete series of manuals is available on the Animal Health Australia website¹
- relevant nationally agreed standard operating procedures (NASOPs).² These procedures complement AUSVETPLAN and describe in detail specific actions undertaken during a response to an incident. NASOPs have been developed for use by jurisdictions during responses to emergency animal disease (EAD) incidents and emergencies
- relevant jurisdictional or industry policies, response plans, standard operating procedures and work instructions
- relevant Commonwealth and jurisdictional legislation and legal agreements (such as the Emergency Animal Disease Response Agreement – EADRA³), where applicable.

1.3 Training resources

EAD preparedness and response arrangements in Australia

The EAD Foundation Online course⁴ provides livestock producers, veterinarians, veterinary students, government personnel and emergency workers with foundation knowledge for further training in EAD preparedness and response in Australia.

1.3.1 Disease-specific training

A WorkCover Queensland training video provides guidance on safe bat handling.⁵

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

2 www.animalhealthaustralia.com.au/what-we-do/emergency-animal-disease/nationally-agreed-standard-operating-procedures

3 www.animalhealthaustralia.com.au/what-we-do/emergency-animal-disease/ead-response-agreement

4 www.animalhealthaustralia.com.au/emergency-animal-disease-training-program

5 www.worksafe.qld.gov.au/resources/videos/films/safe-bat-handling

2

Nature of the disease

Lyssaviruses cause a viral encephalitis (rabies) in mammals. The disease is almost invariably fatal, and is of both public health and animal health significance.

This response strategy covers disease caused by any lyssaviruses that are maintained and transmitted in warm-blooded terrestrial animals (mammals), including bats. These are rabies lyssavirus (RABV), other exotic lyssaviruses and Australian bat lyssavirus (ABLV) – the only lyssavirus reported from Australia. ABLV is considered endemic in the Australian bat population, and reports of ABLV infection in people and animals other than bats are rare.

World Organisation for Animal Health listing

Rabies (due to RABV) is a World Organisation for Animal Health (OIE)-listed disease.⁶

Diseases due to ABLV or other lyssaviruses are not OIE-listed diseases.

2.1 Aetiology

Rabies is caused by infection with viruses of the genus *Lyssavirus*, family *Rhabdoviridae*. There are 17 recognised species of *Lyssavirus*, and some other viruses are awaiting classification (Marston et al 2017, WHO 2018a, ICTV 2019). Key features of the *Lyssavirus* species are shown in Table 2.1.

A number of different categorisation systems, for different purposes, have been developed for lyssaviruses. For example, lyssaviruses have been categorised into phylogroups on the basis of genetic distances and serological cross-reactivity (WHO 2018a).

ABLV is genetically distinct from, but antigenically close to, RABV. ABLV isolates from flying foxes and from the insectivorous bat *Saccolaimus flaviventris* (yellow-bellied sheath-tailed bat) belong to genetically distinct lineages. Genetic variation within each ABLV lineage is narrow (Guyatt et al 2003, Barrett 2004).

2.2 Susceptible species

Lyssaviruses can infect most (if not all) warm-blooded terrestrial animals (mammals), whether as maintenance or spillover hosts (see Section 2.4.2 and Table 2.1).

RABV may adapt and establish epidemiological cycles in a range of mammalian species, including canids, bats and some terrestrial wild animal species. RABV infection in rodents is uncommon

⁶ OIE-listed diseases are diseases with the potential for international spread, significant mortality or morbidity within the susceptible species, and/or potential for zoonotic spread to humans. OIE member countries that have been free from a notifiable disease are obliged to notify the OIE within 24 hours of confirming the presence of the disease.

(Fitzpatrick et al 2014). Birds are not considered to play a significant part in the maintenance or spread of RABV. The susceptibility of Australian native animals is unknown.⁷

ABLV infection has been found in a number of megabat and microbat species,⁸ and all Australian bat species are considered susceptible. On one occasion, spillover infection of ABLV was reported in two horses (in the same paddock), in association with clinical disease. Serological evidence has been found in asymptomatic dogs, indicating probable exposure to the virus. Experimentally, fatal neurological disease, similar to that caused by other lyssaviruses, has been reproduced in mice inoculated with ABLV by peripheral and intracerebral routes (Barrett 2004).

2.2.1 Zoonotic potential

All lyssaviruses are considered capable of infecting people.

Human rabies due to RABV is found wherever the virus is found – primarily through bites from carnivores.

Human contact with bats, with the potential for transmission of ABLV infection, is not uncommon. Only three human cases of ABLV infection have been described to date. All three cases resulted from scratches or bites from bats and presented a clinical picture indistinguishable from rabies (see Section 2.5.1).

2.3 World distribution

For the latest information on the distribution of lyssavirus infection, refer to the OIE World Animal Health Information System.⁹

2.3.1 Distribution outside Australia

The geographic distribution of *Lyssavirus* species is outlined in Table 2.1.

RABV occurs throughout most regions of the world but is absent from many island nations, including Australia.

RABV outbreaks have occurred in the Indonesian island of Flores since 1997 and are moving eastward along the Indonesian archipelago (Tenzin & Ward 2012). In Indonesia, rabies is now endemic in 26 provinces, with only eight provinces free – Riau, Bangka Belitung, DKI Jakarta, Central Java, DI Yogyakarta, East Java, Papua and West Papua (WHO 2020). Australia has supported syndromic rabies surveillance in both Timor Leste and Papua New Guinea since the late 2000s, in collaboration with the animal health agencies of those countries. During this time, rabies infection has not been confirmed in either country (DAWE, pers comm, 2021)

Other bat lyssaviruses have been detected in Europe, Africa and Asia wherever sufficiently sensitive surveillance systems have been used. Hence, it is likely that lyssaviruses occur in microbat populations in most areas of the world.

7 A discussion on the likely susceptibility of Australian native animals is provided by Wildlife Health Australia at www.wildlifehealthaustralia.com.au/Portals/0/Documents/FactSheets/Exotic/EXOTIC_Rabies_in_Wildlife.pdf.

8 In this manual, the term 'megabat' is used to refer to flying foxes, tube-nosed bats and blossom bats; 'microbat' is used for insectivorous species.

9 <https://wahis.oie.int/#/home>

Table 2.1 Lyssavirus species: distribution, maintenance and known spillover hosts

Name	Locality	Hosts
<i>Rabies lyssavirus</i>	Worldwide (except some countries, including Australia) Bat variants are confined to the American continents – insectivorous bats mainly in North America; haematophagous bats in South and Central America, and the Caribbean	Maintenance hosts: <ul style="list-style-type: none"> • Multiple American insectivorous bats; highest frequency in <i>Eptesicus fuscus</i>, <i>Lasionycteris noctivagans</i>, <i>Lasiurus</i> spp., <i>Myotis</i> spp., <i>Pipistrellus</i> spp., <i>Tadarida brasiliensis</i> • Haematophagous (vampire) bats: <i>Desmodus</i> spp. • Carnivores, including Canidae Spillover hosts reported: <ul style="list-style-type: none"> • Insectivorous bat strains: humans, foxes, skunks • Vampire bat strains: mainly cattle, horses, humans • Carnivore strains: several spillover hosts reported, including cats, humans, cattle, horses and wildlife • Poultry^a
<i>Lagos bat lyssavirus</i>	Sub-Saharan Africa One case from France in a fruit bat imported from west Africa (1999)	Maintenance hosts: <ul style="list-style-type: none"> • Fruit bats: <i>Eidolon helvum</i>, <i>Micropteropus pusillus</i>, <i>Epomophorus wahlbergi</i> • Single isolate from insectivorous bat: <i>Nycteris gambiensis</i> Spillover hosts reported: <ul style="list-style-type: none"> • Cats, dogs, water mongoose (<i>Atilax paludinosus</i>)
<i>Mokola lyssavirus</i>	Sub-Saharan Africa	Maintenance hosts: <ul style="list-style-type: none"> • Not known. Has been isolated from shrews (<i>Crocidura</i> spp.) Spillover hosts reported: <ul style="list-style-type: none"> • Cats, dogs, humans, shrews
<i>Duvenhage lyssavirus</i>	Southern and eastern Africa	Maintenance hosts: <ul style="list-style-type: none"> • Insectivorous bats: <i>Nycteris thebaica</i>, possibly <i>Miniopterus schreibersii</i> Spillover hosts reported: <ul style="list-style-type: none"> • Humans
<i>European bat 1 lyssavirus</i>	Europe (continental and Great Britain)	Maintenance hosts: <ul style="list-style-type: none"> • Insectivorous bats, particularly <i>Eptesicus serotinus</i> Spillover hosts reported: <ul style="list-style-type: none"> • Sheep, stone martens (<i>Martes foina</i>), cats, humans
<i>European bat 2 lyssavirus</i>	Europe (continental and United Kingdom)	Maintenance hosts: <ul style="list-style-type: none"> • Insectivorous bats, particularly <i>Myotis daubentonii</i>, <i>M. dasycneme</i> Spillover hosts reported: <ul style="list-style-type: none"> • Humans

Cont'd

<i>Australian bat lyssavirus</i>	Australia	<p>Maintenance hosts:</p> <ul style="list-style-type: none"> Flying foxes (<i>Pteropus</i> spp.) Insectivorous bat: <i>Saccolaimus flaviventris</i> All Australian bat species are considered susceptible. <p>Spillover hosts reported:</p> <ul style="list-style-type: none"> Humans, horses
<i>Aravan lyssavirus</i>	Southern Kyrgyzstan	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Myotis blythii</i> (bat)
<i>Khujand lyssavirus</i>	Northern Tajikistan	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Myotis mystacinus</i> (bat)
<i>Irkut lyssavirus</i>	China	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Murina leucogaster</i> (bat)
<i>West Caucasian bat lyssavirus</i>	Southeastern Europe and Kenya	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Miniopterus schreibersii</i> – Europe, <i>Miniopterus</i> spp. – Kenya <p>(insectivorous bats)</p>
<i>Shimoni bat lyssavirus</i>	Kenya	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Hipposideros commersoni</i> (bat)
<i>Bokeloh bat lyssavirus</i>	Germany	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Myotis nattereri</i> (bat)
<i>Ikoma lyssavirus</i>	Tanzania	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Civettictis civetta</i> (civet)
<i>Lleida bat lyssavirus</i>	Spain	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Miniopterus schreibersii</i> (insectivorous bat)
<i>Gannoruwa bat lyssavirus</i>	Sri Lanka	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Pteropus medius</i> (flying fox)
<i>Taiwan bat lyssavirus</i>	Taiwan	<p>Isolated from:^b</p> <p><i>Pipistrellus abramus</i> (bat)</p>
Unclassified virus		
<i>Kotolahti bat lyssavirus</i>	Finland	<p>Isolated from:^b</p> <ul style="list-style-type: none"> <i>Myotis brandtii</i> (bat)

a Although rabies virus has been detected in poultry, as a spillover host (Baby et al 2015), birds are not considered to play a significant part in the maintenance or spread of rabies virus.

b Only species from which the lyssavirus has been isolated are shown, based on limited reports of the virus; there is insufficient information to categorise these hosts into maintenance or spillover hosts.

Source: Fraser et al (1996), Kuzmin et al (2010), FAO (2011), Marston et al (2012), Aréchiga Ceballos et al (2013), Liu et al (2013), Freuling et al (2013), Baby et al (2015), Gunawardena et al (2016), Nokireki et al (2018), WHO (2018a)

2.3.2 Occurrence in Australia

One suspected occurrence of transmission of RABV was in Tasmania in 1867 and involved several dogs, a pig and a child bitten by one of the dogs (Pullar & McInosh 1954). More recently (in 1987 and 1990), two human cases of overseas-acquired rabies were reported (Bek et al 1992, cited in Sparkes et al 2013; McColl et al 1993).

ABLV has a wide geographical distribution in bats in Australia (Garner & Bunn 1997, Field & Ross 1999, Field 2005, Prada et al 2019, Bat Stats¹⁰). Spillover infection is rare; since ABLV was first identified in 1996, spillover infection has been reported in two horses and three humans in Queensland.

2.4 Epidemiology

2.4.1 Incubation period

RABV

The incubation period for RABV in all mammals, including humans, is highly variable but is typically between 10 days and 6 months. Rarely, it may be longer, even years (Bingham et al 1994, WHO 2018a). Based on a study by Tojinbara et al (2016), Brookes (Research Fellow, School of Veterinary Science, University of Sydney, pers comm, January 2019) derived a median incubation time for RABV in dogs of 21 days and a 95% range of 7–65 days.

Several factors influence the duration of the incubation period in animals, including the virus strain, the virus dose, the distance of the bite site from the central nervous system (CNS) and the richness of the sensory innervation at the site of virus entry into the body. The last two of these factors are most important. For example, the incubation period following a bite on the face or muzzle could be expected to be much shorter than that after a bite on the trunk or limbs.

The incubation period for other exotic lyssaviruses is not well documented but is assumed to be similar to that for RABV.

ABLV

The available information on the incubation period for ABLV in bats, although limited, indicates that it is similar to that for RABV. The incubation period for ABLV in two naturally infected (captive) bats was reported as approximately 30 days and 6–9 weeks, respectively (Field et al 1999, Warrilow et al 2003). In experimental studies, grey-headed flying foxes (*P. poliocephalus*) developed disease 15–24 days after inoculation (McColl et al 2002). In another study, bats developed clinical disease between days 10 and 19 after inoculation (Barrett 2004).

The incubation period for ABLV in the two horses that have been naturally infected is unknown.

The first human case of ABLV, which was caused by the microbat variant, is believed to have had an incubation period of a few weeks (Allworth et al 1996). In the second case, involving the pteropid strain, the incubation period was believed to be 27 months (Hanna et al 2000). In the third case, also involving a pteropid strain, the incubation period was considered to be about 8 weeks (Francis et al 2014a).

10 www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx

OIE incubation period

For the purposes of the OIE *Terrestrial animal health code*, the incubation period¹¹ for rabies due to RABV is 6 months.

2.4.2 Persistence of agent and modes of transmission

Current understanding of the persistence of lyssaviruses and their modes of transmission is largely derived from understanding of RABV and is believed to be similar across all lyssaviruses.

General properties

Key features relevant to persistence of RABV are as follows:

- RABV is comparatively fragile and does not survive for long periods outside the host.
- RABV is stable for several months at 0–4 °C but is rapidly inactivated by heat, ultraviolet light, direct sunlight and desiccation.
- RABV is sensitive to very low pH (<3) or very high pH (>11) (OIE 2014).
- Infectivity is lost when the virus is treated with proteolytic enzymes.
- RABV is inactivated by sodium hypochlorite, 45–75% ethanol, iodine preparations, quaternary ammonium compounds, formaldehyde, phenol, ether, trypsin, β-propiolactone and some other detergents (OIE 2014).

Environment (including windborne spread)

Environmental contamination is of negligible significance in transmission of RABV; this is presumed to apply also to ABLV and other lyssaviruses.

Aerosol transmission of RABV to humans in bat caves has been reported in a very small number of cases under specific conditions (Irons et al 1957, Kent & Finegold 1960, Winkler et al 1973, Tillotson et al 1977 – all cited in Johnson et al 2006).

Fruit could be contaminated by contact with saliva of infected bats; however, there is no evidence to suggest that lyssaviruses (such as ABLV) could be contracted by eating fruit partially eaten by an infected bat (Queensland Health 2020).

Live animals

The lyssavirus lifecycle involves both maintenance and spillover host species. Although lyssaviruses can infect most (if not all) warm-blooded terrestrial animals (mammals), only a limited range of species can act as maintenance hosts (see Table 2.1).

Maintenance hosts are the species that principally sustain the virus lifecycle. They are highly susceptible to the particular virus variant but less susceptible to other types. Successful control of the virus in the maintenance host will lead to eradication of the virus cycle in the ecological community. Maintenance hosts for lyssaviruses include species from the orders Carnivora and Chiroptera (bats).

Spillover hosts are infected mammals of species that do not normally maintain the virus type. Compared with maintenance hosts, in spillover hosts the probability of establishing infection is lower, the clinical signs and pathological course of the disease are less consistent, and virus shedding is lower. Spillover hosts are usually dead-end hosts and rarely transmit infection to other hosts.

¹¹ In the OIE *Terrestrial animal health code*, 'incubation period' means the longest period that elapses between the introduction of the pathogenic agent into the animal and the occurrence of the first clinical signs of the disease (see <https://www.oie.int/index.php?id=169&L=0&htmfile=glossaire.htm>).

The main route of transmission for RABV is contamination of fresh wounds (skin or mucous membranes) with saliva from a clinically affected animal – typically from a bite or, less frequently, from scratching or licking. RABV cannot penetrate intact skin. Respiratory and oral transmission can occur but is considered uncommon (Fischman & Ward 1968, Johnson et al 2006).

Shedding of RABV in experimentally infected animals may begin in the preclinical phase and persists throughout clinical disease. The reported period of preclinical shedding varies with the host species. Dogs, cats and domestic ferrets may be infectious for 10 days before the onset of clinical signs. The World Health Organisation (WHO) refers to contact investigations being relevant for '14 days before symptom onset until death' – which is used for the purposes of this response strategy. In wild animal species (including bats), the period of preclinical shedding is not well documented; it is reported to be up to 2 weeks in skunks and bats, and up to 29 days in foxes (Barrat et al 1999, Spickler 2012).

A significant proportion of bites by clinically affected animals do not result in transmission. This is usually because of a low dose of virus in the bite inoculum, which does not lead to detectable seroconversion. Alternatively, infection may be initiated at the site of inoculation but is cleared before establishment in the CNS. This is known as 'abortive infection'; it does not result in clinical signs of disease but may result in seroconversion (Aguilar-Setien et al 2005, Turmelle et al 2010). There is no evidence that these animals pose a risk of transmission.

Transmission of RABV across the placenta has been reported in several mammalian species, including skunks, humans, dogs, cattle, bats and laboratory rodents (Sipahioğlu & Alpaut 1985, Weese 2011). In exceptional circumstances, transmission from mother to suckling young has been reported (Fischman & Ward 1968).

There are rare reports of dogs surviving rabies or developing chronic infection in western Africa, Ethiopia and India (Fekadu 1993).

It is generally accepted that there is no carrier or latent state for rabies.

Information about the transmission of ABLV in Australian bat populations is provided in Appendix 2.

To date, there is no evidence of transmission of ABLV from species other than bats, although it is assumed that any mammal clinically affected by ABLV is capable of transmitting the virus to another mammal (including people).

Carcasses

As a result of neural spread of lyssavirus from the brain to various organs and tissues during the clinical phase of the disease, the entire carcass is regarded as potentially contaminated with lyssavirus.

RABV does not survive for more than 24 hours in dead animals when temperatures reach 21 °C, but is highly resistant for extended periods at low or freezing temperatures (OIE 2014). The stability of other lyssaviruses is assumed to be similar.

Animal products

Meat and meat products, and casings, including use as animal feed

Any meat and meat products from an animal confirmed or suspected to be infected with a lyssavirus should be regarded as potentially infectious. Thorough cooking is expected to inactivate RABV present in meat or meat products (NYS DOH 2014); it is assumed that the same applies to other lyssaviruses.

Milk and dairy products, including use as animal feed

Milk and milk products from an animal confirmed or suspected to be infected with a lyssavirus should be regarded as potentially infectious. However, pasteurised milk and pasteurised milk products do not pose a risk of RABV transmission (WHO 2018a); it is assumed that the same applies to other lyssaviruses.

Eggs and egg products

Not relevant.

Animal byproducts

Hides, skin, wool and other fibres

Hides, skin, wool and other fibres are not implicated in the natural transmission of RABV; it is assumed that the same applies to other lyssaviruses.

Swill and meatmeal

Ingestion by susceptible animals of swill derived from an animal confirmed or suspected to be infected with a lyssavirus could result in transmission if breaks in the oral mucous membranes are present.

Lyssaviruses are not expected to survive rendering.

Semen and embryos from live susceptible animals

There is no historical evidence of transmission of lyssaviruses through semen and embryos.

Specimens

The highest-risk tissues and fluids from an animal that has died of rabies are the nervous tissues, salivary glands and saliva.

Transmission risk in laboratory situations includes splashing onto mucous membranes and aerosol exposure (Gibbons 2002). Such incidents are very rare and unlikely to occur under the current strict safety standards of Australian laboratories.

Waste products and effluent

Faeces, blood and urine are not thought to contain infectious lyssavirus (Spickler 2012), although viral RNA may be detected in them. Contact with faeces, urine or blood from lyssavirus-infected animals is therefore not considered to pose a risk of transmission (Francis et al 2014b, WHO 2018a, CDC 2019).

People

Although people are considered dead-end hosts for rabies, rare cases of human-to-human transmission of RABV have been reported through transplacental transmission (Sipahioğlu & Alpaut 1985), and through tissue and organ transplants (Gibbons 2002, Jackson 2011, Monroe et al 2014, Zhou et al 2016). Transmission of RABV from humans to other humans (or animals) through biting is theoretically possible but has not been documented (CDC 2019).

The first two human ABLV cases had histories of contact with (Samaratunga et al 1998), and bites from (Hanna et al 2000), clinically ill bats that had signs consistent with ABLV infection. In the 2013 human case, the child was reported to have been scratched on the wrist by a flying fox about 8 weeks before developing clinical signs.

2.4.3 Factors influencing transmission

RABV

Not all bites from clinically affected animals result in rabies, even in the absence of post-exposure vaccination (Hattwick 1974). Transmission is influenced by factors including the virus dose, site of inoculation, virus variant, species and environment (Hattwick 1974, Hamir et al 2011).

The maintenance host species for individual virus variants requires only a small infectious dose and usually sheds significant viral loads in saliva, relative to spillover hosts, which require a larger infectious dose and excrete virus in smaller amounts (DA 2013). Experimentally, higher virus doses result in shorter incubation periods and higher mortality rates in bats and other species (Barrett 2004, Almeida et al 2005).

Epidemics often spread slowly – for example, spread of 30–60 km per year has been reported for fox rabies in Europe (Murray et al 1986). However, this is influenced by migration and seasonal dispersal patterns of the host species. Dog rabies can be spread rapidly to new areas by the movement of infected dogs or by subclinically infected pets moved to new areas by their owners.

Landscape heterogeneity (including topography – natural barriers such as rivers and mountain ranges), population densities, abundance and behavioural characteristics may also play an important role in the spatial spread of rabies (Sparkes et al 2013).

In herds of cattle, sheep and other herbivores, there are often several nearly simultaneous cases, resulting from multiple attacks by a rabid animal.

ABLV

The bats that people (and animals) most often come into contact with are sick, injured or orphaned. This subpopulation presents the primary risk of ABLV exposure for humans and other terrestrial species (Field & Ross 1999) because ABLV infection is more common in these bats, especially those with neurological signs (Barrett 2004). Nationally collated monitoring data show that the prevalence of ABLV infection in bats submitted for testing¹² between 2010 and 2018 ranged between 2.8% and 7.4%,¹³ whereas active surveillance has indicated a prevalence of ABLV infection in the wild bat population of less than 1% (Field 2005).

The ecology of bats may have a major influence on the persistence and transmission of ABLV. For example, the seroprevalence of ABLV in bats submitted for testing varies with species, being lower in microbats (up to 5%) than in megabats (up to 20%) (Barrett 2004, Field 2005). Differences in ABLV seroprevalence and the probability of exposure within these groupings have also been noted.

The frequency of exposure of people to bats may be influenced by season. Heat stress events¹⁴ in summer present a particular risk for potential exposure of people, as large numbers of dead and moribund bats may be found on the ground. The number and duration of these events may increase with warming global temperatures.

Appendix 2 provides more information on the prevalence of ABLV in bats and the factors affecting transmission in Australian bat populations.

12 Bats are submitted for ABLV testing for various reasons, including bat-human or bat-pet contact (eg bites, scratches), neurological signs or unusual behaviour, and bats found dead or euthanased as a result of trauma. Nationally collated data are held by Wildlife Health Australia and published regularly in ABLV Bat Stats (www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx).

13 Figures collated by Wildlife Health Australia and provided by the CSIRO Australian Animal Health Laboratory, Barrett (2004) (with permission), Queensland Health, Wildlife Health Australia subscribers, zoo veterinarians and state/territory wildlife health coordinators.

14 See 'Heat stress in flying-fox camps' from the NSW Department of Planning, Industry and Environment (www.environment.nsw.gov.au/topics/animals-and-plants/wildlife-management/management-flying-foxes/heat-stress-in-flying-fox-camps).

2.5 Diagnostic criteria

2.5.1 Clinical signs

Lyssaviruses cause a viral encephalitis in mammals (rabies) that is almost invariably fatal.

Animals

The signs of rabies from any lyssavirus are assumed to be similar to those seen in animals clinically affected by RABV.

RABV

In all species, the clinical signs of rabies are highly variable. The most consistent signs are acute, significant behavioural changes and unexplained progressive paralysis; however, the clinical presentation of rabies may also be subtle.

Early signs of RABV infection in domestic animals are generally nonspecific, and may include hyperaesthesia at the wound site and a temporary rise in temperature. In livestock, this may be associated with a drop in production (eg of milk). Clinical signs progress to a variety of neurological signs related to the location of lesions in the CNS. Common signs include restlessness, muscle tremors, changes in appetite (increased or decreased), vomiting, diarrhoea, pupillary dilation, hyperreactivity to stimuli, sexual excitement, unusual vocalisation, dysphagia and increased salivation¹⁵ (Spickler 2012). Some animals may become withdrawn and fearful, whereas others display increased aggression.

Classically, clinical signs of rabies have been characterised in carnivores as either the furious (encephalitic) or dumb (paralytic) form of the disease. For example, a dog with the dumb or paralytic form of rabies may remain quiet and lethargic, hiding behind cover and biting only when provoked, whereas a dog with the furious or encephalitic form would show aggression and restlessness. However, the clinical signs of rabies in carnivores will not always fit neatly into either category, and affected animals may show signs of both forms during the course of the disease.

Rabies is more difficult to recognise in young animals: clinical signs are less clear, and biting occurs as part of normal play behaviour.

The clinical signs of rabies in wild animals are highly variable and consistent with those seen in domestic animals. An important common feature in wild animals is the loss of normal shyness and fear of people. This makes such animals particularly dangerous to children, who may wrongly interpret this behaviour as indicating friendliness.

Death usually occurs within 10 days of the onset of clinical signs.

ABLV

Clinical signs in the two horses known to have been naturally infected with ABLV included pyrexia, altered demeanour (dullness), protrusion of the nictitating membrane, and ataxia and gait abnormalities that progressed over 5 days to terminal recumbency and seizures (Annand & Reid 2014, Weir et al 2014).¹⁶

Seropositive but clinically well dogs have irregularly been confirmed in New South Wales and

¹⁵ In livestock, the dysphagia and increased salivation may be misinterpreted as signs of oesophageal obstruction.

¹⁶ A video showing clinical signs in a horse infected with ABLV is available at www.mdpi.com/1999-4915/6/2/909 [scroll to download supplementary material].



Colony of flying foxes, Charters Towers, Australia.

Queensland during veterinary investigations of animal–bat interactions (NSW DPI 2013). Bats infected with ABLV show a range of nonspecific clinical signs, including overt aggression, paresis and paralysis, seizures and tremors, weakness, respiratory difficulties and changes in vocalisation. Affected bats are often found on the ground or low in a tree, and are unwilling or unable to fly. ABLV should also be considered in bats that are injured or trapped in fences or netting because the injury or entrapment could have resulted from neurological signs. The observed clinical duration of disease in 27 ABLV-positive bats that died naturally was up to 9 days (Barrett 2004). Appendix 3 provides guidance on how to manage ABLV risks in captive bats.

Humans

The clinical signs of rabies in humans are well described (DoH 2013). The disease is almost invariably fatal.

All three reported human cases of ABLV infection had progressive fatal neurological disease consistent with that seen in rabies (Samaratunga et al 1998, Hanna et al 2000, Francis et al 2014b). All cases died 3–4 weeks after the onset of disease, after being on intensive life support.

2.5.2 Pathology

Gross lesions

No pathognomonic gross lesions are seen with lyssavirus infection. Lesions secondary to the neurological effects may be seen, including dehydration, ill-thrift, bladder dilation, dilation of the rectal ampulla, recent trauma (such as broken teeth), and evidence of pica.

No consistent macroscopic lesions have been seen in ABLV-infected bats (McColl et al 2002, Barrett 2004). Macroscopic lesions were not reported in ABLV-infected horses (Shinwari et al 2014).

Microscopic lesions

The severity and extent of microscopic lesions in lyssavirus-infected animals are extremely variable, and lesions are often absent.

Microscopically, the most significant lesions in RABV-infected animals are in the CNS, and cranial and spinal ganglia. There is multifocal, nonsuppurative encephalomyelitis and craniospinal ganglionitis, usually with perivascular cuffing; focal and diffuse gliosis; neuronal degeneration; and intracytoplasmic inclusion bodies (or Negri bodies) in the neurones. Negri bodies vary in size with the host – they are large in dogs and cattle. Negri bodies are found most commonly in the neurones of the hippocampus or in the Purkinje cells of the cerebellum in cattle. They are found less frequently in the glial cells, in ganglion cells of the salivary glands and adrenal medulla, and in the retina. Negri bodies are not seen in all cases (Jubb et al 1992, Spickler 2012). Nonsuppurative sialadenitis has also been observed in the mandibular glands of infected dogs (Boonsriroj et al 2016).

Similar lesions have been seen in ABLV-infected bats and horses (Hooper et al 1997, McColl et al 2002, Barrett 2004, Shinwari et al 2014).

Pathogenesis

Natural transmission of RABV is usually through saliva by the bite of a clinically affected animal. After inoculation of virus into a wound, virus generally replicates in local tissues, although high levels of initial inoculum can invade the motor neurone endplates without the need for initial replication (Shankar et al 1991, Scott & Nel 2016). Within hours to days after a bite, virions invade peripheral nerve endings, followed by centripetal movement of virions along axons to the CNS. If infection progresses to clinical disease, progression is invariably irreversible and fatal. From the CNS, virus then invades peripheral nerves, resulting in infection of many peripheral tissues, including salivary glands and skin. Virus infection of salivary acinar cells leads to shedding of large numbers of virions into saliva.

The pathogenesis of other lyssaviruses, including ABLV, is expected to be similar to that of RABV.

2.5.3 Differential diagnosis

Any other causes of neurological dysfunction should be considered as differential diagnoses for rabies. The disease in all mammals is acute, progressive and fatal. Where this is not the case, lyssavirus infection can usually be excluded.

The following conditions should be considered in the differential diagnosis of rabies in non-bat animals:

- viral encephalitides
 - Hendra virus
 - canine distemper and infectious canine hepatitis
 - Aujeszky's disease

- Borna disease
 - eastern, western and Venezuelan equine encephalomyelitis viruses
 - West Nile virus, Japanese encephalitis virus and other flaviviruses
 - various insect-borne reoviruses
- bacterial and mycotic diseases of the CNS, including listeriosis and cryptococcosis
 - poisonings, including by '1080' (sodium fluoroacetate), heavy metals (eg lead), chlorinated hydrocarbon and organophosphate pesticides, urea, or nitrogen trichloride
 - protozoal infections, including babesiosis and toxoplasmosis
 - *Angiostrongylus cantonensis* infection
 - foreign bodies in the oropharynx or oesophagus, and other traumatic injuries
 - acute psychoses in dogs and cats
 - spinal and head injuries
 - transmissible spongiform encephalopathies.

Common aetiologies for neural disorders in flying foxes include spinal and head injuries, and the nematode parasite *Angiostrongylus* spp. (Barrett et al 2002). Other differential diagnoses include lead poisoning, tick paralysis (*Ixodes holocyclus*) in spectacled flying foxes, toxoplasmosis (*Toxoplasma gondii*) and bacterial meningitis (Skerratt et al 1998, Sangster 2012, Sangster et al 2012).

2.5.4 Laboratory tests

Lyssaviruses cause zoonotic disease, and taking and handling samples for laboratory testing presents a risk to human health. Field personnel (eg government or private veterinarians) require adequate protection (eg protective equipment and clothing, rabies vaccination), and should contact the receiving laboratory to seek advice and discuss arrangements before sampling, packing and transporting specimens.

Samples required

Where feasible, suspect carcasses should not be opened and the whole animal should be submitted for laboratory investigation. If the submitter is previously vaccinated, known to have had a rabies titre >0.5 IU within the last 2 years, is wearing appropriate personal protective (PPE), and takes all reasonable steps to avoid disrupting skin integrity (scratches, lacerations, punctures) the following samples may be more feasible to submit:

- submission of whole (severed) head
- submission of whole fresh (chilled) brain
- submission of small brain biopsy (it should be noted that testing a small biopsy increases potential for a false negative result, particularly in herbivores).

For all species, whole animals, severed heads or unpreserved brains should be chilled and forwarded on ice to the testing laboratory. The most valuable tissue for diagnosis of rabies is fresh (unpreserved), chilled brain. Distribution of virus in the brain is usually diffuse but may be localised in some structures – the brain stem is the most consistently reliable area for detection of infectious virus or viral antigen. Other regions of the brain, including the hippocampus, are negative in up to 5% of rabid animals. For this reason, a composite brain sample (including several different parts of brain) is preferred. Formalin-fixed tissues may be used for immunohistochemistry if fresh tissues are not available.

Hendra virus may be an important differential diagnosis for ABLV infection in horses. In such cases, conducting a Hendra virus exclusion test before attempting sampling of the brain is preferable. If Hendra virus is excluded and a brain biopsy is required, submission of the whole animal is preferable. If this is not feasible, appropriately protected operators may obtain a biopsy specimen by removing a small brain sample via the ocular foramen, the occipital foramen or a hole drilled into the skull. (See the **AUSVETPLAN response policy brief *Hendra virus infection*** for advice on human health precautions for sampling animals for Hendra virus testing.)

If the brain cannot be sampled, other suitable tissues include the spinal cord, the trigeminal ganglion, peripheral nerves (taken from points close to the CNS), skin (tactile hair follicles), corneal impression smears and salivary glands. Detection of the virus is less efficient in these samples; use of these samples may lead to a false negative result and failure to recognise potential exposure of other animals to an infected animal. Although a positive result on tissues other than brain can be interpreted as indicating lyssavirus infection, negative results from tissues other than brain should not be relied upon as evidence that lyssaviruses are excluded.

Decomposition may affect the reliability of diagnosis, particularly when using culture methods. A positive result on decomposed tissue can be interpreted as indicating lyssavirus infection. However, negative results from decomposed tissues should not be relied upon as evidence that lyssaviruses are excluded.

Transport of specimens

Where an exotic lyssavirus (such as RABV) is suspected, rather than ABLV, samples should be forwarded to the CSIRO Australian Centre for Disease Preparedness (CSIRO-ACDP), Geelong, through the relevant state or territory government laboratory.

For ABLV exclusion testing, the following procedure applies:

- In states other than New South Wales or Queensland, all samples should be submitted to the relevant state or territory government laboratory, which will forward samples to CSIRO-ACDP. If a potential human exposure has occurred, the state or territory department will immediately notify the relevant public health department.
- In New South Wales, samples should be submitted to the Elizabeth Macarthur Agricultural Institute (EMAI).¹⁷ EMAI may conduct its own polymerase chain reaction (PCR) testing (which is considered as diagnostic) and may send some samples to CSIRO-ACDP for additional testing.
- In Queensland
 - if there is, or is suspected to be, potential human exposure, the incident should be referred to the local public health unit¹⁸
 - if an animal has not had human contact, the Biosecurity Sciences Laboratory¹⁹ should be contacted about options for exclusion testing.

Samples should be submitted in accordance with agreed jurisdictional protocols.

For further information, see the **AUSVETPLAN management manual *Laboratory preparedness***.

Packing specimens for transport

Tissues should be kept cold for storage and transport to the laboratory. Ideally, they should not be

¹⁷ www.dpi.nsw.gov.au/about-us/science-and-research/centres/emai

¹⁸ www.health.qld.gov.au/system-governance/contact-us/contact/public-health-units

¹⁹ www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/health-pests-weeds-diseases/sample-testing/submitting

placed in formalin, as this precludes their use in, or reduces their reliability for, all the principal diagnostic tests. However, unpreserved and formalin-fixed samples of other tissues should be collected at postmortem to aid differential diagnosis.

Freezing of specimens should be avoided unless chilling is not possible. However, freezing should be considered if long-term storage is necessary. Freezing does not affect the major diagnostic tests, but thawing of large specimens may increase the time to obtain results.

2.5.5 Laboratory diagnosis

Laboratory diagnosis relies on a suite of detection assays. Laboratory testing must include, wherever possible, at least two tests that are appropriate for the diagnostic request. The tests selected will depend on the context of the case – for example, the species, clinical signs, human and animal contact and the need to exclude exotic lyssaviruses. The reliability of a diagnostic test is dependent on several factors. Given optimal equipment and operator performance, the two primary areas that affect test performance are specimen quality, and the quality and design of the reagent probe (antibody or primer). The most common reasons for a false negative result are examination of a single, rather than a composite, brain sample; testing only tissues other than brain; diagnostic antibody or primer mismatch, particularly with unusual lyssavirus types; and severe decomposition of the specimen.

CSIRO-ACDP tests

Table 2.2 Laboratory tests currently available at CSIRO-ACDP for diagnosis of lyssavirus infection

Test	Specimen required	Test detects	Time taken to obtain result
Agent detection			
FAT	Fresh brain	Viral antigen	4 hours
Immunohistochemistry	Formalin-fixed brain	Viral antigen	2 days
qPCR	Fresh tissue	Viral genome	4 hours
Agent characterisation			
Virus isolation	Fresh brain	Live virus	5 days
PCR and sequencing	Fresh brain, cultured virus	Viral genome	3–4 days
Serology			
FAVN (serum neutralisation test)	Serum	Antibodies	3 days

FAT = fluorescent antibody test; FAVN = fluorescent antibody virus neutralisation; PCR = polymerase chain reaction; qPCR = real-time PCR
 Source: Information provided by CSIRO-ACDP, 2020 (refer to CSIRO-ACDP for most up-to-date information)

Other tests

Fluorescent antibody test

The fluorescent antibody test (FAT) is the initial test of choice for the diagnosis of lyssavirus (including RABV and ABLV) infections in animals because it is rapid and reliable, and can detect a wide range of lyssaviruses. It involves the application to a brain tissue smear of fluorescein-labelled antibody conjugate directed against viral nucleocapsid protein antigens. Given the antigenic similarity of all lyssavirus nucleoproteins, the test can recognise most lyssavirus types, including rabies variants, ABLV and other lyssavirus types, and could be expected to detect previously unrecognised lyssavirus variants. This test does not distinguish between different lyssaviruses.

Molecular genetic techniques – PCR and sequencing

PCR tests detect the presence of viral nucleic acid. They are rapid and reliable and so are included in the first-line testing response. PCR tests can be highly specific, only recognising particular viral types. Because of the potential, particularly in bats, for unrecognised lyssavirus variants to be present, type-specific PCR tests alone must not be relied upon to exclude infection, particularly where potentially infectious contact (human or animal) has occurred. Sequencing assays provide definitive evidence of virus type.

Identification and differentiation of different lyssaviruses requires characterisation of the viral genome by molecular genetic techniques (eg PCR and sequencing).

Immunohistochemistry

Immunohistochemistry is an antigen detection assay that is performed on sections of fixed tissue. If appropriately selected anti-rabies antibodies are used, this test can be highly sensitive and specific on formalin-fixed tissues.

Culture methods

Cell cultures use mouse neuroblastoma cells. Mouse inoculation has historically been a reliable test, but is no longer used as a routine detection test on animal welfare grounds. Culture methods are appropriate when virus needs to be amplified for detailed antigenic and genetic characterisation.

Histology

Histology may be useful for detecting lesions consistent with lyssavirus infection and for differential diagnosis.

Serology

Serology tests are of no value for diagnosing current lyssavirus infection in animals but are useful for detecting seroconversion post-exposure and for confirming vaccine responses. After vaccination – usually around 2–4 weeks after the end of the primary course – serum is collected and tested in a neutralising antibody assay.

The response to vaccination is based on the serum neutralising antibody level. A neutralising antibody level of 0.5 IU/mL indicates that the animal's immune system has adequately recognised the vaccine antigen and is primed to respond to virus challenge. It does not indicate a 'protective' threshold but does indicate that the animal has responded as expected to the vaccine. RABV vaccines provide some degree of cross-protection against ABLV; however, the degree of cross-protection provided is not known.

2.6 Resistance and immunity

The susceptibility of different host species to lyssavirus variants is known to be variable. Generally, species in which a virus variant is well adapted are more susceptible to that variant, but less susceptible to variants adapted to other species.

The role of passive maternal antibodies in providing immunity to ABLV and other lyssaviruses in free-living populations is presumed to be limited, as the prevalence of naturally acquired antibodies in these populations is low. In one study, flying fox pups born to rabies-vaccinated mothers had antibody profiles suggestive of maternally derived antibodies; by 3–4 months of age, the antibody levels in these pups were very low or absent (Barrett 2004).

There is very little immune stimulation following lyssavirus inoculation into a bite site, as lyssaviruses are well adapted to 'hiding' from immune surveillance (Cliquet et al 2009). This allows them to replicate successfully over long incubation periods. Immune stimulation occurs once the CNS is overwhelmed by the infection. Hence, antibody is usually undetectable at the beginning of clinical disease but rises to very high levels in serum and cerebrospinal fluid in advanced disease and with prolonged survival (eg with humans kept on life-support systems).

Lyssavirus antibodies are rarely present in unvaccinated healthy animals and humans. Where they are found, their significance is difficult to interpret, given the current knowledge of lyssavirus immunology. It is likely that antibodies signify prior exposure to virus and limited viral replication, probably in nonneural tissues (Speare et al 2013), but probably not recovery from clinical disease. As an example, on several occasions, clinically well dogs who have interacted closely with bats have been found to be seropositive for ABLV. Investigations of these cases did not indicate any pathology or development of neurological disease consistent with active infection.

Active immunity to RABV – and some other lyssaviruses, including ABLV – can be induced by RABV vaccination (Barrett 2004, Brookes et al 2005).

2.7 Vaccination

Domestic animals

RABV

Parenteral RABV vaccines are widely used overseas for rabies control. Most contain inactivated (killed) antigen, and are considered safe and inexpensive. A live recombinant canarypox virus expressing the rabies lyssavirus glycoprotein has also been registered for use in cats in the United States (WHO 2013, Brown et al 2016).

Oral vaccines are an important tool to control the spread of RABV in wildlife populations overseas (see below), and may also be useful for vaccinating free-roaming and feral dogs. Some oral vaccines that use attenuated ('live') virus have been associated with vaccine-induced rabies cases and/or may not be effective in all species (Blanton et al 2007). Vaccinia–rabies glycoprotein recombinant oral vaccines have been used extensively in the United States (Maki et al 2017), but their efficacy in some species is limited, and they have also occasionally caused local and disseminated vaccinia infections in humans. More recently, human adenovirus vectors have been used for oral RABV vaccines. Europe has also used modified attenuated strains (SAD strains) of RABV, which rarely cause disease in target or nontarget species (Hostnik et al 2014). Inactivated antigens are not effective as oral vaccines.

Based on experimental studies, existing RABV vaccines may provide some degree of cross-protection only within phylogroup 1 lyssaviruses (WHO 2013).²⁰

The importation and use of vaccines in Australia is regulated – see Section 4.3.8 for more details on the importation and permitted use of rabies vaccines in Australia.

Vaccination strategies for RABV

Vaccination before exposure (pre-exposure prophylaxis) is the standard method for protecting animals from developing rabies following exposure to RABV. To control dog-mediated rabies, WHO guidelines recommend recurrent (annual) campaigns with at least 70% coverage of the dog population (WHO 2018a). A postvaccinal titre of 0.5 IU is considered indicative that vaccination has induced an adequate immune response in an animal (WHO 2018a). Vaccination of livestock is not essential for RABV eradication but may be desirable to prevent sporadic cases in these animals and the subsequent risk to humans. Pleasure horses, valuable stud animals and any other animal that comes into frequent human contact could be considered for vaccination.

In animals that do not have current pre-exposure prophylaxis, vaccination may be used following exposure to RABV to prevent the development of disease. In animals, post-exposure administration of rabies immunoglobulin, with or without vaccination, may be effective in preventing disease (Hanlon et al 2002) but is unavailable for use in animals in Australia.

ABLV

There is no vaccine specific for ABLV. RABV vaccines are understood to provide some degree of cross-protection against ABLV; however, the degree of cross-protection provided against each strain of ABLV and the vaccination regimen required to elicit optimal cross-protection are not known (Hooper et al 1997, Brookes et al 2005, WHO 2018a).

Post-exposure prophylaxis of animals, through RABV vaccination as soon as possible after exposure to ABLV, is the only available treatment that may help to prevent the development of disease. In Australia, one RABV vaccine may be used, under permit, in terrestrial animals (except pigs) as post-exposure prophylaxis to prevent ABLV (see Section 4.3.8). Vaccination of animals with RABV vaccine before exposure to ABLV (pre-exposure prophylaxis) is only allowed under relevant Australian Pesticides and Veterinary Medicines Authority permits.²¹

Wildlife

RABV

Mass vaccination of wildlife species has been used overseas to control rabies due to RABV (WHO 2018a). Vaccines may be delivered using either the parenteral route (eg through trap–vaccinate–(mark)–release (TV(M)R) strategies) or the oral route (vaccines distributed through the landscape). Before implementing mass vaccination campaigns in wildlife, the safety of vaccines in target and nontarget species should be assessed. The safety and efficacy of rabies vaccines and bait administration in native Australian wildlife species have not been assessed.

TV(M)R involves capturing live wildlife in cage traps and vaccinating them by intramuscular injection. It has been used for rabies management for urban skunks and raccoons in North America. This method could be used to conserve endangered species. It could also be used to manage rabies in wildlife that

²⁰ Categorisation into phylogroups is based on the amino acid at position 333 of the transmembrane glycoprotein (Seif et al 1985, Badrane et al 2001). Phylogroup 1 includes RABV, Duvenhage lyssavirus, European bat lyssaviruses 1 and 2, ABLV, *Aravan lyssavirus*, *Irkut lyssavirus*, *Bokeloh bat lyssavirus* and *Khujand lyssavirus*.

²¹ <https://portal.apvma.gov.au/permits>



Mass vaccination has been used overseas to control rabies.

live in areas inhabited by people where population reduction methods and oral baiting methods are unsuitable or unacceptable to the public – or where satisfactory oral baits have not been developed. However, implementing a TV(M)R strategy is resource-intensive.

ABLV

Barrett (2004) explored the use of RABV vaccine in Australian bats.

Parenteral RABV vaccine may be used under permit in individual bats in Australia as post-exposure prophylaxis to prevent disease due to ABLV (see Appendix 3). Mass vaccination of wild bat populations against ABLV is not feasible as no effective delivery method is available.

Humans

Safe and efficacious RABV vaccines are available for human use, for both pre- and post-exposure prophylaxis. Pre-exposure vaccination (with RABV vaccine) of people who handle bats and could be exposed to ABLV minimises the risk of human infection.

The Australian immunisation handbook (ATAGI 2018) outlines vaccination schedules for people. Relevant human health authorities should be contacted for current information about vaccination of people and lyssavirus post-exposure management.

2.8 Treatment of infected animals

There is no known effective treatment for clinically affected animals.

2.9 Control overseas

Control of rabies is primarily by control of the disease in the maintenance host(s) of the lyssavirus involved. Understanding the population dynamics of maintenance host species is important for the control of rabies.²² Rabies control programs in maintenance hosts may vary with the species involved. These host-specific control programs are typically complemented by epidemiological surveillance, and communication and education programs. Where available, pre-exposure vaccination of domestic carnivores (dogs, cats and ferrets) may also be implemented to limit the potential for human exposure. Post-exposure vaccination of potentially exposed domestic animals (particularly carnivores) may be undertaken in some countries but may not be offered in countries where pre-exposure vaccination of these animals is mandated or strongly encouraged.

Canine- or dog-mediated rabies contributes to more than 98% of all human rabies cases (PRP 2017) and so is a major focus for rabies control overseas. Mass vaccination strategies, integrated with epidemiological surveillance, dog population control (birth control) and education programs, have been used to successfully eradicate canine rabies in a number of countries (Sparkes et al 2013, WHO 2018a). Detailed guidance is available from WHO (WHO 2018a) or through the Blueprint for Rabies Prevention and Control (PRP 2017). The OIE may also endorse Member country official control programs for dog-mediated rabies. The OIE requirements for official control programs to achieve this endorsement are outlined in the OIE *Terrestrial animal health code*.²³

For rabies maintained in some non-bat wild animal species (such as foxes), the wild animal maintenance host may be vaccinated orally (through distribution of vaccine baits) for host-specific control programs. This approach has been used in Europe to control rabies in foxes and raccoon dogs (PRP 2012). Detailed guidance on this approach is available through the Blueprint for Rabies Prevention and Control (PRP 2017). However, oral vaccination of wild animal maintenance hosts is not always feasible or practicable – for example, it is not used to control rabies in wild bat populations and has not always been effective in controlling rabies in other wild animal populations.

²² A number of studies have investigated the population dynamics of dogs in northern Australia (Dürr & Ward 2014, Hudson et al 2017, Brookes et al 2020).

²³ www.oie.int/en/what-we-do/standards/codes-and-manuals

3

Implications for Australia

3.1 Potential pathways of introduction

Potential pathways for the introduction of exotic lyssaviruses, including rabies lyssavirus (RABV), include:

- illegal entry of an infected dog or other mammal
- legal entry through quarantine of an infected but undiagnosed dog
- entry of an infected bat.

Since Australia has strict import requirements, border controls and active surveillance in place, the probability of entry of exotic lyssaviruses is considered to be low to very low. However, the spread of RABV in neighbouring countries to the north will increase the risk of introduction to Australia.

Dogs and cats are common pets in Australia. Although there is no evidence of a maintenance cycle of rabies in cats, they can transmit rabies. Australia also has a high density of feral cats, so cats could contribute to further spread of the disease.

Australia has widespread and abundant populations of wild animals that are known to be maintenance hosts of rabies in other countries (including bats, the European red fox, and canids such as feral dogs; dingoes and dingo hybrids are also potential maintenance hosts).

More detail is provided in the **AUSVETPLAN resource document *Rabies: overview of national rabies (canine variant) surveillance and outbreak risk***.

Australian bat lyssavirus (ABLV) is considered endemic in bat populations in Australia.

3.2 Social, economic and environmental effects

The socioeconomic consequences of RABV occurring in Australia would result mainly from its public health importance. The death of people from rabies, combined with the ongoing need for post-exposure treatment of members of the public following dangerous contact with suspected infected animals, may have a significant social effect. Post-exposure treatment (vaccination and use of human rabies immunoglobulin) of people and post-exposure vaccination of animals may also be expensive. At times, global supply of vaccine or immunoglobulin is limited.

The effects from RABV control programs in animals – in particular, the cost of researching, developing and implementing a wild animal vaccination program – could be significant. Orders to impound, control and euthanase animals are likely to provoke community concern. Implementation of wild animal control or vaccination programs could do the same, domestically and internationally. There may also be community concern about the potential role of bats in RABV transmission (see discussion on ABLV, below).



Black flying foxes (*Pteropus alecto*), Kakadu National Park, Northern Territory, Australia.

Impacts of the occurrence of other exotic lyssaviruses in Australia will vary with their maintenance host(s) and the cycle of transmission that establishes in Australia.

Spillover ABLV infection of humans and non-bat animals is rare, and there have been no reports in Australia of transmission of ABLV from people or non-bat animals. Consequently, the occurrence of ABLV in Australia has had minimal social and economic effects. The main costs have been associated with prophylactic vaccination of at-risk people, and post-exposure management of people and animals. A degree of societal concern is indicated by the coverage of bat-related diseases (such as ABLV and Hendra virus infection) in the mainstream media. This may lead to a negative perception of bats as disease transmitters and the desire to have them removed from public places.

Bat lyssaviruses may, albeit rarely, cause infection in terrestrial hosts to set up perpetuated epizootic cycles (Leslie et al 2006). In the unlikely event an endemic ABLV cycle established in non-bat species in Australia, the social and economic effects are expected to be similar to those anticipated for RABV.

3.3 Critical factors for an Australian response

General (lyssaviruses)

- Lyssaviruses are believed to have a broad host range and are considered potentially capable of infecting all mammalian species, including humans.
- The key maintenance host species of lyssaviruses are mammals from the orders Chiroptera and Carnivora.
- The ecology and demographics of potential maintenance host species (including domestic dogs) are not well known, and may be affected by human behaviour and sociology.
- The susceptibility of Australian native animals to lyssaviruses is unknown.
- Lyssaviruses cause a viral encephalitis that is almost invariably fatal.
- Lyssaviruses typically have a long incubation period; the clinical signs of infection may be nonspecific, and infection can only be confirmed postmortem.
- The main mechanism of spread is the transfer of saliva, usually through biting or scratching. Exposure through the skin or mucous membranes is usually required for infection to occur.
- The pathogenesis – including the period of preclinical shedding – of lyssaviruses in bats is incompletely understood.

- Lyssaviruses are fragile and do not persist in the environment.
- Handling lyssavirus-infected animals poses a public health risk (eg to response personnel, and owners and carers of animals).

Exotic lyssaviruses – RABV

- Effective human and animal RABV vaccines are available. However, the global supply of RABV vaccine (animal and human) is limited, and sufficient vaccine for Australia’s response may not be readily available, particularly early in the response.
- No oral RABV vaccines are available in Australia. This may make effective control of the disease difficult if it is present in free-roaming or wild animal populations.
- There may be insufficient rabies-vaccinated field staff early in the response. This may limit response capability in the initial stages and/or put pressure on response staff who are not appropriately vaccinated to participate.
- Rabies cycles can be broken by restricting the contact of healthy animals with infected ones – for example, by restricting the movements and density of susceptible maintenance host species.
- Response personnel may have limited experience in the safe handling of potentially infected animals.
- In different locations, community norms about pet management may affect control measures such as movement restrictions.
- There may be limited availability of appropriate quarantine facilities to detain and monitor suspect or exposed animals.
- Indiscriminate culling of maintenance hosts is generally ineffective, may increase population turnover rates and may have negative repercussions on community support for disease control programs. Indiscriminate culling may also raise public concern for wildlife, and cause long-term damage to relationships between animal health agencies and animal owners and carers, with negative impacts on other initiatives.
- Wild dog control programs may need to be adjusted to support rabies eradication.
- Legislative changes may be required to allow vaccination and release of wild dog populations.
- The potential role of Australian wildlife in the epidemiology of RABV is unknown.
- If wildlife are involved in the transmission of RABV, there will be challenges with undertaking effective surveillance.
- The efficacy and safety of available RABV vaccines for Australian wildlife species are unknown.
- There may be public concern for the wellbeing of Australian wildlife species, and the potential effects on these species of both the disease and disease control measures.

Exotic lyssaviruses – other

- The epidemiology and pathogenesis of exotic lyssaviruses other than RABV are less well studied and less well understood, complicating decisions on the choice of appropriate response measures.

ABLV

- There has been no demonstrated occurrence of ABLV infection in mammals other than bats, humans or horses; as a result, the level of risk to other animals (eg dogs, cats) is unknown.
- The degree of cross-protection provided by RABV vaccine for ABLV infection is unknown.

4

Policy and rationale

4.1 Introduction

All lyssaviruses are considered capable of causing infection and rabies in humans and other mammals. The management of lyssaviruses will vary with their epidemiology, particularly whether they are capable of establishing an endemic cycle in non-bat species (such as rabies lyssavirus – RABV) or have an endemic cycle only in bat species (such as Australian bat lyssavirus – ABLV).

4.1.1 Summary of policy

For RABV, the default policy is to quickly eradicate infection to prevent spread to animals and humans using a combination of strategies, including:

- tracing and surveillance to determine the source and extent of infection, and to provide evidence to support proof of freedom from the disease
- epidemiological assessment to aid understanding of the incident and inform response decision making
- movement controls on susceptible animals in declared areas to minimise spread of infection
- destruction of animals that are highly likely to be infected to remove the most dangerous source of virus
- destruction and testing of animals showing clinical signs of rabies, or quarantine and monitoring to assess their RABV status
- post-exposure vaccination and monitoring of asymptomatic, potentially exposed domestic and captive animals, or destruction where it is not possible to establish the disease status and there is an ongoing risk to humans and other animals
- mass vaccination of maintenance host species (eg dogs) and targeted other animal groups in declared areas to protect animals from infection and reduce exposure of humans
- enhanced biosecurity in affected areas to prevent spread of infection
- management of animal welfare issues that arise
- monitoring of wild mammals and, if disease establishes in these populations, consideration of vaccination
- linkage and coordination of public health and environmental authorities so that they are co-responders
- a public awareness campaign to facilitate cooperation from animal owners and the community, including government and nongovernment authorities.

If RABV becomes established in a wild animal (including bat) population, or if eradication from the domestic animal population is either not feasible or not practicable, long-term control strategies will need to be developed (see Section 4.4).

For ABLV, the default policy is to manage the risks to exposed and potentially exposed domestic animals and captive wildlife, and the potential associated risks to humans, using a combination of strategies, including:

- testing, where possible, to establish the ABLV status of bats, domestic animals and wildlife suspected of being infected and/or posing a transmission risk to other animals and humans
- quarantine and monitoring of animals that may have been exposed to ABLV-infected animals and are showing clinical signs
- euthanasia of animals that may have been exposed to ABLV-infected animals and are showing clinical signs if the potential transmission risks cannot be adequately managed through quarantine and monitoring
- isolation and monitoring of asymptomatic animals that may have been exposed to ABLV-infected animals, with or without post-exposure vaccination
- euthanasia of asymptomatic animals that may have been exposed to ABLV-infected animals, if the potential transmission risks cannot be adequately managed through isolation and monitoring
- use of biosecurity, monitoring and vaccination to manage ABLV risk to bats in captive populations or temporary care
- linkage and coordination of public health and environmental authorities
- a public awareness campaign to educate, and facilitate cooperation from, animal owners and the community, including government and nongovernment authorities
- ongoing disease investigation and surveillance of bat species to improve understanding of disease ecology and epidemiology, and assist in risk assessment
- further investigation and targeted surveillance if ABLV is found in a non-bat species.

For lyssaviruses other than RABV and ABLV, the recommended approach is, where possible, to quickly eradicate infection to prevent spread to domestic and wild mammals, and humans. Where this is not possible (eg if an endemic transmission cycle is established in bat species), the recommended approach is to manage the risks to exposed and potentially exposed domestic mammals and captive wildlife, and humans. The strategies that will be implemented will be informed by the strategies that would be used in response to RABV and ABLV. They will consider the epidemiology of the lyssavirus and specific variant, and the ecology and population dynamic of the maintenance host species involved.

In managing lyssaviruses, population reduction by culling susceptible animals is generally not appropriate, but population control (eg through breeding reduction) may be useful.

4.1.2 Case definition

For the purpose of this manual, a case of lyssavirus infection is defined as an animal that demonstrates the presence of lyssavirus genome or antigen in tissues or secretions.

Notes:

- AUSVETPLAN case definitions guide when a response to an emergency animal diseases (EAD) incident should be undertaken. AUSVETPLAN case definitions do not determine when international reporting of an EAD incident is required.
- Viral gene sequence analysis or other molecular testing will be used to identify the lyssavirus involved and guide the choice of response measures.
- Positive serology in the absence of genome or antigen does not constitute a case but may warrant further investigation to determine whether infection is present.

- At the time of an outbreak, revised or subsequent case definitions may be developed (with the agreement of the Consultative Committee on Emergency Animal Diseases – CCEAD).

This manual provides guidance on how to manage animals that may have been exposed to ABLV – see Section 4.3. Additional information is available from a number of Australian state and territory websites, including Biosecurity Queensland²⁴ and the NSW Department of Primary Industries.²⁵

4.1.3 Cost-sharing arrangement

In Australia, ABLV and rabies (due to RABV) are included separately as Category 1 EADs in the Government and Livestock Industry Cost Sharing Deed in Respect of Emergency Animal Disease Responses (EAD Response Agreement – EADRA).²⁶ Category 1 diseases are those for which costs will be shared 100% by government.

Lyssaviruses other than RABV and ABLV are not categorised in the EADRA.

4.1.4 Criteria for proof of freedom

The World Organisation for Animal Health (OIE) recommendations for declaring freedom from rabies due to RABV²⁷ are provided in Chapter 8.14 of the *Terrestrial animal health code*.

For other exotic lyssaviruses, there are no specific recommendations for proof of freedom.

Section 7.2 provides more detail on proof of freedom following the occurrence of RABV or another exotic lyssavirus in Australia.

ABLV is considered endemic in wild bat populations in Australia, and demonstrating proof of freedom is not applicable.

4.1.5 Governance

Governance arrangements for the response to EADs are outlined in the **AUSVETPLAN Overview**.

Information on the responsibilities of a state coordination centre and local control centre is available in the **AUSVETPLAN management manual Control centres management (Parts 1 and 2)**.

Disease-specific governance issues

Since lyssaviruses are considered zoonotic and wild animals may be involved, establishment of a multiagency threat assessment team within the state coordination centre and/or local control centre is recommended.

The chief veterinary officer (CVO) in the affected state or territory is responsible for managing animal health risks and instituting animal health control action within that jurisdiction. The chief health officer of the affected state or territory is responsible for managing public health risks and instituting public health control action within that jurisdiction.

Environment and wildlife agencies, and other relevant authorities should also be involved in the response.

²⁴ www.publications.qld.gov.au/dataset/australian-bat-lyssavirus-information-for-veterinarians

²⁵ www.dpi.nsw.gov.au/_data/assets/pdf_file/0007/513547/Australian-Bat-Lyssavirus-guidelines-for-veterinarians.pdf

²⁶ Information about the EAD Response Agreement can be found at www.animalhealthaustralia.com.au/what-we-do/emergency-animal-disease/ead-response-agreement.

²⁷ The OIE *Terrestrial animal health code* defines rabies as a disease caused by rabies virus (referred to as rabies lyssavirus or RABV in this manual).

In the response to an exotic lyssavirus (including RABV) incursion, involvement of the Liaison – Other Agencies function (in state coordination centres and local control centres) is strongly recommended to facilitate community liaison, to help ensure that control measures applied are appropriate to the context of the outbreak, and to facilitate community support for implementation of the measures.

4.2 Public health implications

Work health and safety (WHS) legislation in Australia requires businesses and workers to, as far as reasonably practicable, ensure the health and safety of themselves and others. Jurisdictional WHS authorities should be consulted on individual jurisdictional legislative requirements.

Measures to manage the risks of human lyssavirus infection include:

- minimising contact between humans and potentially infected animals
- ensuring that people at high risk of exposure have current RABV immunity
- providing suitable personal protective equipment (PPE) and ensuring that PPE is worn by those at risk (see Section 4.3.5)
- developing protocols for managing potential lyssavirus exposures
- providing appropriate first aid equipment and training
- providing information, training, instruction or supervision to protect people from lyssavirus risks (including for handling animals, decontaminating reusable equipment and using PPE).

Links to resources on the safe handling of bats are provided in Section 1.3.

4.2.1 Vaccination of people

Safe and effective vaccines for protecting humans against RABV are available. There are two protocols for RABV vaccination: pre-exposure vaccination and post-exposure vaccination (ATAGI 2018).

Specific vaccines for protecting humans against other lyssaviruses have not been developed. Available vaccines against RABV are believed to offer some cross-protection against some other lyssaviruses (WHO 2018a).

4.2.2 Handling of animals

Detailed guidance for public health units on managing potential exposures of people to lyssaviruses is available in the *Rabies and other lyssaviruses (including Australian bat lyssavirus) exposures and infections* National Guidelines for Public Health Units (DoH 2013).

Minimising the likelihood of exposure

The most important way of reducing lyssavirus exposure risk to people is to avoid handling potentially infected animals, wherever possible.

Potentially rabid animals should be approached and handled only when necessary and then with extreme caution. They should only be approached by appropriately trained and RABV-vaccinated personnel. If it can be done without risk to the operator, every effort should be made to capture and safely confine the animal. If the animal cannot be safely captured or confined, and therefore constitutes a risk to people or other animals, it should be immediately euthanased (see Section 4.3.11).

Use of tranquilisers delivered via blow-dart or air-powered dart gun to sedate the suspect animal is recommended to minimise risks to both animals and response personnel. If tranquiliser darts are not available, nets or dog-catching poles with stout rope or wire loops may be used to capture and handle small animals, and ropes or other restraints for large animals. Containers, cages or pens must be very strongly constructed and well secured. If a suspect animal is first presented at a veterinary clinic, it should be hospitalised away from other animals. Confined suspect animals should be under veterinary care.

Personnel should use a high level of hygiene and safety measures when handling infected and suspect animals – whether the animals are alive or dead. All field and laboratory staff should be trained in the correct use of PPE and decontamination of reusable equipment. Contamination of the environment with aerosols and saliva is highly possible; therefore, all personnel who are associated with the program, and are handling animals and animal parts must take all necessary precautions. This includes the use of appropriate PPE (see Section 4.3.5).

Because ABLV is endemic in the Australian bat population, bats should only be handled by appropriately vaccinated and trained personnel using appropriate PPE (see Section 4.3.5). Members of the public should not handle bats; if a bat requires rescuing, they should contact the nearest wildlife care organisation or veterinarian for assistance. In an emergency situation where contact with a bat is unavoidable (eg if a child is at imminent risk of exposure), all efforts should be made to cover exposed skin before removing the bat from the immediate area.

First aid and medical assessment

People may be potentially exposed to lyssaviruses from any bite or scratch (even those that are seemingly minor or trivial), or contact of broken skin or mucous membrane with the saliva or neural tissues from any potentially rabid animal (DoH 2013).

Whenever people have potentially been exposed to lyssaviruses (even if they have current RABV pre-exposure vaccination):

- first aid must commence at once to remove as much virus as possible from exposed tissue
- wounds should be thoroughly cleansed. The affected area should be immediately and thoroughly washed with soap and copious water for 15 minutes. A virucidal antiseptic such as povidone-iodine or alcohol (ethanol) should be applied to wounds after washing (WHO 2018b)
- if the eyes, nose or mouth are exposed to the animal's saliva or neural tissues, the area should be flushed thoroughly with water.
- medical advice should be sought urgently (eg from the local public health unit, hospital or general practitioner).

Other post-exposure management

Under medical supervision, other post-exposure management will be required. This needs to be initiated as soon after exposure as possible. However, because lyssaviruses may have a long incubation period, medical advice about post-exposure prophylaxis should be sought regardless of the time that has elapsed since the exposure.



Bat eating fruit.

4.2.3 Food safety

Meat and meat products from lyssavirus-infected animals must not enter the human food chain.

Raw milk from a lyssavirus-infected animal should not enter the human food chain, but milk and dairy products that have been pasteurised are not considered to present a risk for lyssavirus transmission (see Section 2.4.2).

Although fruit could be contaminated by contact with saliva from infected bats, there is no evidence to suggest that lyssaviruses (including ABLV) can be contracted by eating fruit partially eaten by an infected bat (Queensland Health 2020). Because lyssaviruses are not likely to remain viable for more than a few hours outside the host animal, fruit that has been harvested, stored and transported for sale is safe to eat.

4.3 Control and eradication policy

The approach to control and eradication of a lyssavirus will depend on the specific virus and variant, whether it has established an endemic transmission cycle, and the host species involved (its location, ecology and population dynamics). Decisions on control actions will be based on risk assessment and subject to ongoing review as more information on the incident becomes available.

RABV

For RABV, the default policy is to quickly eradicate infection to prevent spread to animals and humans. The approach taken will involve a combination of strategies, informed by an epidemiological assessment and the circumstances of the incident.

Resources should be focused on measures in higher-risk areas and on higher-risk premises. However, response measures may differ for different animals in these areas and premises depending on the species, the likelihood of exposure to RABV, the potential role in transmission of RABV and the associated potential risks to public health.

If RABV becomes established in Australian wild animal (including bat) populations, or if eradication from the domestic animal population is either not feasible or not practicable, long-term control strategies will need to be developed (see Section 4.4).

Management of domestic and captive animals under investigation for RABV

Decisions on how to manage domestic and captive animals under investigation during a RABV incident will be made case by case, informed by risk assessment. This is because:

- infected animals may show a range of clinical signs, which are not pathognomonic for RABV infection
- the incubation period may be prolonged
- the infective period of cases is relatively short (presumed to be up to 14 days before the onset of clinical signs), but the time of onset of clinical signs may be unknown
- in many instances, the nature and timing of any contact with, or possible exposure to, confirmed or probable cases of RABV infection will be uncertain.

Where there are potential risks to human health, the risk assessment should be made jointly by the relevant animal health and public health agencies.

In determining the management of domestic and captive animals under investigation for RABV infection, the risk to public health will have an overriding influence on decision making; if this risk cannot be adequately managed, the animal should be euthanased and tested for infection.

Domestic and captive animals showing clinical signs or behavioural changes consistent with RABV infection

Domestic and captive animals showing clinical signs or behavioural changes consistent with RABV infection and **with known exposure to a confirmed case** (likely to be within its infective period) are highly likely to be infected (probable cases) and should be euthanased and tested or isolated and observed. Where the risk of infection is relatively high (highly consistent clinical signs), euthanasia and testing is recommended.

For domestic and captive animals showing clinical signs or behavioural changes consistent with RABV infection but with no known exposure to a confirmed case, the options for management are:

- euthanasia and testing
- quarantine and monitoring for 14 days – animals with clinical disease due to RABV will show clinical progression to death within this timeframe; if this does not occur, the disease is not due to RABV infection and alternative diagnoses may be explored.

The risk assessment to inform decisions on management of these animals should consider:

- the nature and onset of the clinical signs (and so the level of suspicion that these are genuinely signs of RABV infection)
- the existence and strength of any epidemiological links to confirmed cases of RABV infection – not all contact with infected animals will result in exposure to RABV infection, because of either the nature of the contact or its timing (eg if not within the expected period in which an infected animal was infective)
- the resources available for quarantine and monitoring of animals – because RABV-infected animals pose a public health risk, quarantine should be in secure facilities
- community support for the response options – if owners or carers believe that their animals will be euthanased if they report any possible signs of RABV infection, irrespective of whether the animal is infected, this may result in failure to report possible cases and undermining of disease control efforts.

Asymptomatic domestic and captive animals with strong epidemiological links to confirmed or probable RABV cases

Asymptomatic domestic and captive animals with strong epidemiological links to confirmed or probable RABV cases are relatively likely to be infected.

Strong links include:

- known to have been bitten, scratched or had other potentially infectious contact with an animal known or highly suspected to be infected (eg consistent clinical signs)
- high suspicion of contact with an animal known to be infected.

The risk that the exposed animal becomes a future source of transmission can be minimised by:

- post-exposure vaccination and isolation for a further 35 days. If the animal develops clinical signs consistent with rabies at any point in time, euthanasia and testing is recommended
- euthanasia (note that testing of an animal early in the incubation period is likely to be negative regardless of the infectious state of the animal).

Asymptomatic domestic and captive animals with other epidemiological links to confirmed or probable RABV cases

While most asymptomatic domestic and captive animals with other epidemiological links to potential sources of RABV will not be infected, some will, and are likely to progress to clinical disease and pose a future risk of infecting others.

Other epidemiological links include potential for infectious contact with an animal highly suspected, but not known to be infected (eg in household contact with animal that is clinically consistent with rabies, but has not been tested).

The risk that the exposed animal poses a risk as a future source of transmission can be minimised by the following measures:

- Post-exposure vaccination and isolation for a further 35 days. If the animal develops clinical signs consistent with rabies within 35 days of vaccination, euthanasia and testing is recommended. If the animal develops clinical signs consistent with rabies more than 35 days after vaccination, isolate and observe the animal for a further 10 days, or euthanase and test.
- Isolation and observation for at least 6 months with an obligation to report clinical signs consistent with rabies. If the animal develops clinical signs consistent with rabies at any point, euthanasia and testing is recommended.
- Euthanasia (note that testing of an animal early in the incubation period is likely to be negative regardless of the infection state of the animal).

ABLV

Because ABLV is endemic in the Australian bat population and vaccine cannot be administered to free-flying populations of Australian bats, its eradication is not feasible. Confirmation of ABLV occurs postmortem, so management of confirmed cases is not required beyond appropriate disposal of the carcass and potentially contaminated materials (see Section 4.3.12). However, the risks to exposed and potentially exposed domestic animals, and the potential associated risks to humans, will be managed.

Appendix 3 provides guidance on managing ABLV risks in captive bats. Specific information for veterinarians on how to assess and respond to the risk of potential transmission of ABLV from bats

to domestic animals is provided on a number of state and territory websites, including Biosecurity Queensland²⁸ and NSW Department of Primary Industries.²⁹

Should ABLV establish an endemic transmission cycle in non-bat animals, other options for its control will need to be developed (see Section 4.4).

4.3.1 Epidemiological assessment

Epidemiological assessment draws on multiple sources of information to build understanding of the disease and how it is behaving in an outbreak. This informs response decision making.

RABV

If RABV is detected in Australia, the key objectives for an epidemiological assessment will be to identify the:

- variant involved and its maintenance host(s)
- spatial distribution of infected and lyssavirus-free animals, including involvement of free-roaming and wild animals (including bats)
- source of infection
- incidence of clinical disease and predicted incidence of subclinical infection
- pathways of spread and the predicted likely size of the outbreak
- risk factors for the presence of infection and susceptibility to disease.

Epidemiological assessment, and tracing and surveillance activities (see Section 4.3.3) in an EAD response are interrelated activities. Early findings from tracing and surveillance will be inputs into the initial epidemiological assessment (eg considering the spatial distribution of infection). The outcomes of the initial epidemiological assessment will then guide decisions on subsequent tracing and surveillance priorities. The outcomes of the epidemiological assessment will also be used to guide the selection of other appropriate response measures (eg application of movement controls) and to assess the progress of disease control measures.

Ongoing epidemiological assessment will also contribute evidence to support any later claims of disease freedom.

ABLV

The response to the exposure or potential exposure of a domestic animal to ABLV will be based on current understanding of the epidemiology of ABLV. Epidemiological assessment should explore whether the incident presents a change in this understanding and so whether additional, or alternative, measures are warranted (see also Section 4.4 and Appendixes 1–4).

4.3.2 Quarantine and movement controls

Guidance on declared areas and premises classifications can be found in the **AUSVETPLAN guidance document *Declared areas and allocation of premises definitions in an emergency animal disease response***.

Quarantine

The use of quarantine in the response to RABV and ABLV is outlined in Sections 4.3 and Appendix 4.

²⁸ www.publications.qld.gov.au/dataset/australian-bat-lyssavirus-information-for-veterinarians

²⁹ www.dpi.nsw.gov.au/_data/assets/pdf_file/0007/513547/Australian-Bat-Lyssavirus-guidelines-for-veterinarians.pdf

Movement controls

In the response to detection of RABV in Australia, controls may be placed on the movement of infected or potentially infected animals and contaminated or potentially contaminated things. Section 6 outlines the recommended movement controls for live animals, carcasses, animal products and byproducts, waste products and effluent, vehicles, equipment, and other items that might be contaminated in the event of an incident of RABV in Australia.

Appendix 3 outlines the management of ABLV risk in bats in captivity and care. A number of Australian state and territory websites provide more detailed information on the management of ABLV in domestic animals – for example, the Biosecurity Queensland website³⁰ and the NSW Department of Primary Industries PrimeFact 1541³¹ include information for veterinarians and provide guidance for managing non-bat animals under investigation for ABLV infection.

4.3.3 Tracing and surveillance

Guidance on tracing and surveillance can be found in the **AUSVETPLAN guidance document *Tracing and surveillance***.

Tracing

Rapid trace-back and trace-forward of the movements of animals (including captive bats) that have had direct contact with a confirmed case of lyssavirus infection should be undertaken.³²

The trace-back period (used to help identify the source of infection) is informed by the expected incubation period, which may be prolonged for lyssaviruses. For RABV, there is evidence that the median incubation period in dogs is 21 days and that most (95%) will develop clinical signs within 65 days of exposure (see Section 2.5.1). If the potential exposure event is unknown, trace-back over a 6-month period (in domestic animals and captive bats) is advisable, where practicable. Rarely, the incubation period for lyssaviruses may be longer than 6 months, and a longer trace-back period may be considered if initial tracing does not identify a probable source.

The trace-forward period (used to help identify other animals or people that may be infected) is informed by the expected period during which the case was infectious.

The priority trace period for all species should cover the 14 days before the onset of clinical signs or behavioural changes in the confirmed case up until the time that the animal was euthanased or died.

If the date of onset of clinical signs or behavioural changes is not known, then the trace period could be considered to be 14 days before the death or euthanasia of the animal. There is some evidence that most clinically affected animals will progress to death in a shorter period (eg 4 days for ABLV; Barrett 2004); this shorter period may be used to prioritise tracing activities.

Animals reported to have bitten people should be traced as a priority (as part of integrated bite case management; see also Section 7.1).

Tracing should include consideration of contact with susceptible wild and free-roaming animals, acknowledging that tracing of wild animals is unlikely to be practical in most circumstances. Where possible, information should be collected about the potential for wild animal species to have been

30 www.publications.qld.gov.au/dataset/australian-bat-lyssavirus-information-for-veterinarians

31 www.dpi.nsw.gov.au/_data/assets/pdf_file/0007/513547/Australian-Bat-Lyssavirus-guidelines-for-veterinarians.pdf

32 The Australian Government Department of Agriculture, Water and the Environment will work with export establishments to trace relevant exported animals and commodities whose status may be affected by the outbreak. The department will notify importing countries of any affected consignments and manage them as required by the importing government authority.

exposed for at least 30 days³³ before the onset of clinical signs or behavioural changes in a confirmed case until the time the animal was euthanased or died. This will help to inform surveillance activities.

Follow-up investigation and management of potentially exposed animals identified by tracing should be prioritised based on the likelihood of transmission, the potential for further transmission (leading to animal and public health risks) and the potential consequences for disease control activities.

If disease occurs in a food-producing animal, animal products and byproducts that may have entered the food chain should be traced (eg meat and meat products derived from the animal, milk³⁴ collected from 14 days before the onset of clinical signs until the time of death, milk products derived from this milk).

Animal products or byproducts from infected animals that may have been used in the production of biological products (eg vaccines and other therapeutics) should also be traced. However, tracing of animal products and byproducts is a lower priority than tracing of potentially exposed live animals.

If livestock need to be traced, information management systems should be used to support tracing activities, as well as farm records, and interviews with farm workers and managers. Databases for the National Livestock Identification System and documents such as National Vendor Declarations or Animal Health Statements should be used to assist with tracing and epidemiological investigations.

Surveillance

If RABV is detected in Australia, surveillance will initially aim to:

- identify the source of infection
- determine the extent of spread and the maintenance host species involved
- identify new cases and animals (and people) at risk of infection (eg through exposure to potentially infected animals).

Surveillance will later be aimed at assessing the progress of disease control activities and providing evidence to support later claims of RABV freedom.

Surveillance of wild and free-roaming mammal populations should also be considered if there are links between these populations and known infected animals (see also Section 4.3.14 and the **AUSVETPLAN operational procedures manual *Wild animal response strategy*** [to be updated]).

Prioritising of surveillance should be risk based. It should consider the likelihood that subclinical infection may be present, and the consequences of ongoing disease transmission and dissemination.

See Section 7 for further details on surveillance procedures and prioritisation, and their contribution to providing evidence to support declarations of freedom from RABV.

The detection of ABLV in a bat is expected and would not warrant additional surveillance. If ABLV is detected in a non-bat animal, increased surveillance of local wild and free-roaming mammals may be undertaken to facilitate identification and understanding of any changes in the expected epidemiology of the disease.

33 The period of preclinical shedding of lyssaviruses in wild animal species is not well documented but has been reported to be up to 29 days in foxes (see Section 2.4.2).

34 The tracing of fresh milk is only necessary to the point at which it is established that the milk has been pasteurised.

4.3.4 Zoning and compartmentalisation for international trade

Where it is not possible to establish and maintain disease freedom for the entire country, establishing and maintaining disease-free subpopulations, through zoning and/or compartmentalisation,³⁵ may be considered.

In the case of a limited disease outbreak, a containment zone³⁶ may be established around the areas where the outbreak is occurring, with the purpose of maintaining the disease-free status of the rest of the country outside the containment zone.

All zoning applications would need to be prepared by the Australian Government in conjunction with the relevant jurisdiction(s) and agreed to by the CCEAD.

Compartmentalisation applications would require input from the relevant industries.

Recognition of both zones and compartments must be negotiated between the Australian Government and individual overseas trading partners. Zoning and compartmentalisation would require considerable resources that could otherwise be used to control an outbreak, and careful consideration will need to be given to prioritising these activities as the resulting competition for resources could delay the quick eradication of the disease and the recognition of disease freedom.

Agreements between trading partners take time to develop, consider and finalise, due to the need to provide detailed information on activities such as biosecurity, surveillance, traceability and diagnostics to support the approach that is developed. An importing country will need assurance that its animal health status is not compromised if it imports from an established disease-free zone in Australia and trading partners may not accept a zoning or compartmentalisation proposal, regardless of the information provided. Eradication of disease may be achieved before zoning or compartmentalisation applications are finalised.

The OIE guidelines for zoning and compartmentalisation are in Chapters 4.4 of the OIE *Terrestrial animal health code*.

4.3.5 Biosafety and biosecurity for personnel

To minimise the risk of exposure, all people who work with potentially infected animals or handle lyssaviruses should have current RABV vaccination and wear appropriate PPE. The PPE should be chosen based on the assessed level of risk, the task and the animal species. Appropriate PPE may include:

- puncture-resistant gloves
- puncture-resistant gauntlets to protect the forearms (eg if handling animals)
- long pants and long-sleeved shirt
- water-resistant dressings to cover cuts and abrasions
- safety eyewear or face shield to protect the face and mucous membranes from bites, scratches, and contact with saliva and neural tissues (including a P2 respirator or similar if there is a risk of aerosols)
- enclosed footwear.

Hand hygiene should be undertaken after removing PPE.

³⁵ With zoning, the disease-free subpopulations are defined primarily based on geography. With compartmentalisation, the disease-free subpopulations are defined primarily by management practices (such as the biosecurity plan and surveillance practices of enterprises or groups of enterprises).

³⁶ The OIE defines a 'containment zone' as an infected zone within a previously free country or zone, which includes all suspected or confirmed cases that are epidemiologically linked and where movement control, biosecurity and sanitary measures are applied to prevent the spread of, and to eradicate, the infection or infestation. The Australian Government Department of Agriculture, Water and the Environment commissioned a report on what would be required for the establishment of containment zones in Australia. This report is available at <https://www.ausvet.com.au/wp-content/uploads/2019/03/Containment-zones-formatted.pdf>.



In Australia, dogs and cats can be vaccinated against rabies in preparation for export.

4.3.6 Biosecurity for equipment

Lyssaviruses do not survive long outside a host, and most fomites are not considered a transmission risk. However, equipment that is contaminated with saliva or neural tissues from potentially infected animals should be either disposed of or decontaminated. Personnel handling this equipment should use appropriate PPE (see Section 4.3.5).

4.3.7 Animal welfare

Guidance on managing animal welfare can be found in the **AUSVETPLAN operational manual *Livestock welfare and management***.

The implementation of disease control measures (such as quarantine or confinement of animals) should be monitored for any welfare implications, particularly when the measures are applied over a prolonged period or in populations of animals that are normally free roaming. Welfare should also be monitored when trap–vaccinate–(mark)–release programs are implemented (see Section 4.3.14).

4.3.8 Vaccination

In Australia, one parenteral RABV vaccine has been issued a minor use permit by the Australian Pesticides and Veterinary Medicines Authority (APVMA). The permit allows dogs and cats in Australia to be vaccinated in preparation for export. It also allows terrestrial animals, other than pigs, to be vaccinated in the response to an incident of rabies or ABLV. Full details of the permit are available through the APVMA's PUBCRIS website.³⁷ Use of the vaccine is under the control of the CVO for each jurisdiction in Australia. Any variation to the manufacturer's vaccination protocol will be at the discretion of the state/territory CVO, in consultation with the CCEAD.

Importation of other rabies vaccines (including oral vaccines) would be subject to the issuing of import permit(s) from the Australian Government Department of Agriculture, Water and the Environment. Supply and use of the vaccine in Australia will require an emergency permit and consent to import from the APVMA. Importation, distribution, use and disposal of a vaccine that is a genetically modified organism must also be licensed by the Office of the Gene Technology Regulator, or permitted under an Emergency Dealing Determination by the minister responsible for gene technology, or other relevant and appropriate processes.

³⁷ <https://portal.apvma.gov.au/pubcris>

Specific considerations for RABV

For RABV, vaccination reduces the number of susceptible animals in an area and has been the cornerstone of many effective overseas rabies control programs. However, vaccination is not appropriate for animals with clinical signs that are reasonably believed to be due to RABV. Vaccination may be effective in preventing progression to clinical disease in any potentially exposed mammal without clinical signs suggestive of RABV – see the discussion on managing domestic and captive animals under investigation for RABV infection in Section 4.3.

In general, priorities for vaccination of animals (in descending order) are:

- maintenance host species (eg dogs, foxes)
- other animals with close epidemiological links to the incident and close contact with people (eg pets)
- other carnivores (especially on premises where cases have occurred in non-carnivores)
- other mammals with close contact with people (eg pets, recreational horses) but without close epidemiological links to the incident
- other mammals (eg livestock) if RABV is cycling in wild animal populations.

There may be a special need to protect susceptible zoo animals and other groups of animals.

For each of the above priority categories:

- animals in a restricted area (RA) would take priority over animals in a control area (CA), which would, in turn, take priority over animals in the outside area (OA) (see Section 5)
- vaccination will be dependent on the availability of adequate vaccine supplies.

Further prioritisation of vaccination of maintenance host species (eg dogs) may be context-specific. For example, free-roaming and controlled dogs may be a high priority in remote communities, but free-roaming dogs may be a lower priority than controlled dogs in urban environments.

Section 4.3.14 provides details on the use of vaccination in wild or free-roaming animal populations.

Vaccination may occur at central points or by house-to-house vaccination (particularly in RAs, where congregations of animals will be discouraged), or using a combination of both.

All vaccinated animals should be identified (eg by microchipping or collars); the method chosen for identification should take into consideration issues such as permanency, traceability, context (eg visual identification, such as ear tattooing, may be preferable in free-roaming or wild animals), species and animal welfare concerns.

Specific considerations for ABLV

Pre-exposure RABV vaccination of animals (as prophylaxis) for ABLV is not currently permitted in Australia. This situation would be reviewed if ABLV infection becomes established in domestic or wild non-bat animals (see Section 4.4).

Post-exposure RABV vaccination will be considered in managing risks associated with ABLV in domestic animals that do not show clinical signs or behavioural changes suggestive of ABLV but may have had contact with a bat that tests positive for ABLV or is of unknown status.

Guidance on the RABV vaccination of captive bats to manage ABLV risks is provided in Appendix 3.

4.3.9 Treatment of infected animals

Treatment of animals with clinical disease is ineffective.

4.3.10 Treatment of animal products and byproducts

Products and byproducts from animals infected with any lyssavirus must not enter the food chain (see Section 4.2) or be used to produce biological products (eg vaccines, therapeutics) but should be disposed of (see Section 4.3.12).

Alternatives to destruction may be considered for products derived from animals in which exposure and infection are possible but unlikely and the animal is not clinically diseased. Alternatives would be considered case by case, subject to risk assessment. Alternative treatments for meat and meat products include thorough cooking or other heat treatment; for milk and dairy products, pasteurisation removes the risk of lyssavirus transmission.

There is no evidence for transmission of rabies via semen or embryos.

4.3.11 Destruction of animals

Destruction plans should be developed for each premises on which animals may be euthanased. Guidance on destruction methods can be found in the **AUSVETPLAN operational manual *Destruction of animals***.

Animals with clinical signs consistent with lyssavirus infection should be euthanased and tested, or isolated and observed. Where the risk of infection is relatively high (highly consistent clinical signs, history of known exposure to infected animal), destruction and testing is recommended.

Euthanasia of animals with a lower index of suspicion of lyssavirus infection, but considered exposed, potentially exposed or dangerous contact animals, may be warranted, but alternative measures for these animals may also be appropriate (see Section 4.3 for guidance on managing animals in an RABV and ABLV incident, respectively).

In the response to RABV, care must be taken with any policy that involves widespread destruction of animals. Experience has shown that this approach is ineffective, costly and unpopular, and can result in owners illegally moving animals to avoid having them euthanased. Guidance on the use of alternative population control measures (such as desexing) is provided in Section 4.3.17.

Destruction methods

Infected animals (whether alive or dead), and their excretions and secretions should be handled with care and while wearing appropriate PPE to avoid potential exposure to live virus through abraded skin or mucous membranes (eg eyes and mouth; see Section 4.3.5).

When selecting destruction methods, preserving opportunities for sampling for disease should be considered. Destruction by shooting into the head, although occasionally necessary for safety reasons, can result in damage to brain tissues and limit the amount of brain tissue available for diagnostic testing. It is therefore less preferred than other methods of euthanasia.

Where a suspect animal can be safely confined (eg in a crush or crush cage), restrained in a bag, or held by a skilled, vaccinated and appropriately trained assistant wearing appropriate PPE, an intravenous or diluted intraperitoneal barbiturate overdose may be administered by a veterinarian who has been vaccinated against RABV. In situations where restraint is more difficult, intramuscular sedation may be given before administering a euthanasia solution.

Small animals, including bats, may be anaesthetised using anaesthetic gas before euthanasia. This would be feasible, for example, if the bat, or its container or bag could be fitted into an induction chamber, or a large dog mask could fit over a small bat contained within a bag to administer the anaesthetic gas. Both techniques facilitate access and administration of euthanasia drugs to the anaesthetised animal without compromising human health and safety. Drugs should only be administered by a veterinarian who has been vaccinated against RABV.

4.3.12 Disposal of animals, and animal products and byproducts

Disposal plans should be developed for each quarantined premises. Guidance on disposal options and methods can be found in the **AUSVETPLAN operational manual *Disposal***.

For any lyssaviruses, dead animals, animal products and byproducts, and potentially contaminated items (that cannot be cleaned and decontaminated) will be disposed of in a biosecure manner. The disposal method chosen will be influenced by the type and volume of material to be disposed of, resources available, the local environment, the prevailing weather, legislative requirements (including environmental protection legislation) and the risk of spreading the disease.

Where possible, disposal will be by incineration, ensuring that all contaminated material is completely burned. Where incineration is not practical, other methods (such as deep burial and rendering) may be considered, based on risk assessment.

Appropriate WHS measures should be undertaken when handling potentially infectious material for disposal (see Sections 4.2 and 4.3.5).

Decontamination of all equipment and machinery involved in on-site disposal will be required.

Disposal must also be in accordance with the requirements in Section 6, and auditable in terms of biosecurity, traceability and financial requirements.

4.3.13 Decontamination

Decontamination plans should be developed for each premises to be decontaminated. General guidance on decontamination can be found in the **AUSVETPLAN operational manual *Decontamination***.

Housing, examination and postmortem areas that may be contaminated with fresh saliva or other infectious material (eg neural tissue) should be cleaned and decontaminated regularly with warm, soapy water or a suitable disinfectant. Clothing and footwear that is potentially contaminated should also be cleaned and decontaminated regularly.

During decontamination, a high level of hygiene and safety measures for personnel is required. It is preferable for vaccinated people with a demonstrated titre to decontaminate areas. Contamination of materials with aerosols and saliva is a possibility, and appropriate PPE should be worn (see Section 4.3.5).

4.3.14 Wild animal management

RABV

If the disease is detected in wild or free-roaming mammals, the population of interest needs to be defined as early as possible. The primary concern will be the maintenance hosts relevant to the variant of RABV (eg the European red fox, feral dogs, dingoes and dingo hybrids). Control of RABV in some other species, notably cats, will also be a high priority to prevent secondary transmission to people.

Wild animal experts (including experts on the ecology of free-roaming and wild dogs and cats, as appropriate) and Indigenous community leaders must be consulted in planning, monitoring, surveillance and control programs. These programs may include measures to limit the movements of populations, if appropriate. (Section 6.2.1 also provides guidance on managing the movements of domestic and free-roaming dogs in urban and remote communities.) Measures should not be introduced that are likely to disperse wild animals. The cultural significance of dogs and dingoes to Indigenous communities should be considered when developing management plans.

The priority is to identify the maintenance host(s), initiate vaccination and, as appropriate, monitor other susceptible species.

The extent of wild animal control areas will be determined on the basis of:

- epidemiological features of the index case
- biology of the maintenance host(s)
- previously known or acquired information on the populations of susceptible species in the risk areas.

RABV vaccination is the preferred option for control of rabies in free-roaming and wild animals. For RABV, mass vaccination of free-roaming or wild canids around an outbreak site can confer herd immunity and act as a barrier for the spread of the disease.

Vaccination options are as follows:

- **Parenteral vaccination.** This may be feasible for some free-roaming animals that can be handled if there is owner support for vaccination (and so assistance to catch and handle the animals).
- **Oral vaccination.** Once a particular wild animal species has been identified as the maintenance host, an oral vaccination program may need to be developed and implemented for this species. This will be based on the most recent information on vaccine types, baiting technology, vaccination strategies, host ecology and other relevant information. It will also ultimately depend on the ability to import vaccine, which will depend on regulatory process and assessment. Consideration needs to be given to the cost-effectiveness of different options, the efficacy of vaccines and bait types for the host in question, the safety of the vaccine in humans and other nontarget species (eg endangered native animals), the thermostability of the vaccine and bait, and the socioecological conditions that may influence options for vaccination strategies.
- **Trap-vaccinate-(mark)-release (TV(M)R).** TV(M)R may become the only option if an oral vaccine or an efficient bait has not been developed for a species or is not available in Australia. It may be useful for vaccinating wild animals, and where owned but free-roaming dogs are present and not able to be handled. TV(M)R can also be used with a buffer perimeter zone of oral vaccination. (TV(M)R is currently prohibited in some jurisdictions by feral animal control laws, and amendments to legislation may be required to permit these activities.)
- **Visual identification.** Marking vaccinated animals in an obvious visual way will be useful to provide opportunity for re-trapped, previously vaccinated animals to be recognised and thus help prevent re-vaccination, and to inform decisions on how to manage these animals and animals bitten by them. A number of methods are available – for example, ear tattooing, daubing the animal with oil-based paint or fitting the animal with a coloured collar. However, each has disadvantages – paint-based identification may be temporary; collars may be ‘re-gifted’ to other animals or lost, or cause welfare issues (eg strangling).

In overseas rabies control programs, population reduction through culling wild or free-roaming mammals has been counterproductive. New animals move into depopulated territories, with behaviours such as increased fighting and territory protection that can lead to an increased rate of infection. Any

existing population reduction (culling) programs for wild dogs may need to be temporarily stopped or prohibited during a response to prevent this from occurring and to allow adequate vaccination coverage in wild dogs.

Population reduction through culling may be considered in a few specific situations after risk assessment – for example, if there is confidence that infection is present in only a discrete, isolated population and that all infected animals can be removed. The risk assessment should consider the species, size, extent and ecology of the target population; and the potential risks of lyssavirus spread that can be associated with population reduction. If used, population reduction needs to be managed concurrently with control measures in domestic animals. Concurrent vaccination of wild and free-roaming animals should also be considered.

As an alternative, population management strategies (eg fertility control through desexing) may be used in conjunction with vaccination to prevent an increase in the number of free-roaming dogs (as maintenance hosts) in an area.

For further information on wild animal control, and other procedures, see the **AUSVETPLAN operational procedures manual *Wild animal response strategy*** [to be updated].

ABLV

Wild animal management for ABLV is limited to preventing potential ABLV exposure of people and domestic animals through contact with bats (see also Section 4.3.16 on preventive measures). This is because bats are the only wild animals implicated in the transmission of ABLV in Australia. Destruction of wild bats or their habitat is not permitted nor effective in the control of ABLV.

4.3.15 Vector management

Not applicable.

4.3.16 Public awareness and media

Guidance on managing public information can be found in the **AUSVETPLAN resource document *Biosecurity incident public information manual***.³⁸

RABV

Public information messaging will be important early in the response to an occurrence of RABV in Australia, to provide information about the public health aspects of the lyssavirus, what constitutes a risk, where to obtain advice, how to report suspect animals, appropriate clinical management of animal bite cases, the progress of eradication and events of public interest. Appropriate messages and communication channels may vary considerably, depending on the community affected – adaptation of messages and channels for urban and remote communities should be carefully considered.

The public should be encouraged to report any bites from dogs or other animals, the presence of stray dogs, or unusual behaviour in wild animals.³⁹ They will also be encouraged to effectively confine their animals. Guidelines on measures to be adopted by the public should be readily available at veterinary and medical clinics. Poor or slow communication messages could lead to ineffective and unnecessary culling of some animals, as well as owners illegally moving animals from a declared area to avoid having them euthanased, potentially leading to wider spread of the disease.

³⁸ BIPIM Part 1 Public Information Policy in the 'Resource document' section of the 'AUSVETPLAN manuals and documents' webpage (www.animalhealthaustralia.com.au/our-publications/ausvetplan-manuals-and-documents).

³⁹ Reporting pathways may be context-specific, and should be developed and agreed early in the response by animal health and public health agencies.

The roles and responsibilities of veterinary and medical practitioners, local government, community leaders, and wildlife and public health authorities should be clearly identified in all communications and made widely known. Veterinary practitioners are required to report all suspect cases of rabies in animals. Local government and public health authorities will be involved in rabies control measures.

Campaigns to educate the public about rabies should be conducted at schools, community centres, health centres, workplaces and other places of mass gatherings, and through the available media (including social media). Any campaign should ensure a consistent public message from all relevant authorities.

National coordination of public communications if RABV is reported in Australia may occur through:

- activation of the National Biosecurity Communication and Engagement Network⁴⁰ to coordinate animal health information, and liaise with public health and environmental agencies
- activation of the National Health Emergency Media Response Network to coordinate public health information, and liaise with animal health and environmental agencies. The Australian Government Department of Health will produce and manage public and media messages (including appropriate public health warnings) about the human health aspects of the incident.

Key communication messages for dog-mediated rabies are provided in Appendix 5.

ABLV

Because ABLV is endemic in the Australian bat population, there are ongoing public communications about the disease, and preventing and managing exposure in people and animals. Key aspects of this messaging include:

- to prevent exposure of people, advice
 - to bat carers and others who work with bats that they must be vaccinated and trained, and always use appropriate PPE
 - to members of the public that they should not handle bats; if they encounter an injured or sick bat, they should contact wildlife care groups or veterinarians for assistance
 - to use wildlife-friendly fruit tree netting and paddock fencing,⁴¹ to prevent bat entanglements that may lead to rescue attempts
 - to prevent contact between pets/other domestic animals and bats
 - to be particularly aware at times when increased interactions between bats and humans/animals are expected, such as breeding seasons and predicted heat stress events
- in the event of possible exposure of people, advice on the need to perform immediate first aid and to urgently seek medical advice
- in the event of possible exposure of domestic animals, advice to seek veterinary advice.

This messaging is routinely provided by animal health, public health and wildlife health agencies and organisations.

⁴⁰ Previously known as the Primary Industries National Communication Network (INCN). More information is available at www.outbreak.gov.au/about/biosecurity-incident-national-communication-network

⁴¹ See www.wildlifefriendlyfencing.com/WFF/Friendly_Fencing.html

4.3.17 Other strategies

Population control

Although widespread destruction is likely to be counterproductive, use of surgical or nonsurgical population control methods for free-roaming or semi-owned domestic animal maintenance host populations is an important component of rabies control. Control of breeding reduces the recruitment of naive susceptible hosts into the population.

Other

To complement the public information campaign, a tourism management plan, developed by governments and industries, may be required to mitigate potential impacts on Australia's domestic and international tourism industry.

4.3.18 Stand-down

Guidance on the stand-down of EAD responses can be found in the **AUSVETPLAN management manual Control centres management, Part 1**.

In the event of an outbreak due to RABV, stand-down of the response will occur once RABV has been eradicated; when eradication of RABV is no longer considered feasible, cost-effective or beneficial; or when the National Management Group formally declares that the outbreak is over. Relief and recovery activity will need to continue after disease control and eradication programs have wound down.

4.4 Other control and eradication options

In certain circumstances, eradicating RABV may not be feasible or practicable – for example, if RABV becomes established in certain wild or free-roaming animal populations (including the Australian bat population).

In such circumstances, a long-term coordinated control program would need to be developed through consultation between governments, industries and other relevant stakeholders. Pre-exposure vaccination programs using rabies vaccines may need to be considered. Particular care would be needed to address the public health risks for potential high-risk groups (eg wildlife carers, veterinarians, pet owners, children).

The approach to ABLV control in Australia may need to be reconsidered if an ABLV transmission cycle establishes in domestic, free-roaming or non-bat wild animals.

4.5 Funding and compensation

Details of the cost-sharing arrangements can be found in the EADRA.⁴² Details of the approach to the valuation of, and compensation for, livestock and property in disease responses can be found in the **AUSVETPLAN operational manual Valuation and compensation**.

⁴² www.animalhealthaustralia.com.au/what-we-do/emergency-animal-disease/ead-response-agreement

5

Declared areas and premises

Declared areas will be used in the response to the detection of rabies lyssavirus (RABV) in Australia (see Sections 5.1–5.4).

Declared areas and premises are not used to manage the risk of Australian bat lyssavirus (ABLV) in Australia.

5.1 Declared area definitions

Detailed guidelines for declared areas are provided in the **AUSVETPLAN guidance document *Declared areas and premises classifications***.

5.1.1 Restricted area (RA)

For RABV, an RA will be declared to encompass all infected premises (IPs) and dangerous contact premises (DCPs), and include as many suspect premises (SPs), trace premises (TPs) and dangerous contact processing facilities (DCPFs) as practicable.

The size of the RA will be determined following a risk assessment that considers the RABV variant, the host species involved, the environment and ecology of the host species, and the history of animal movements. The RA may be as small as an individual IP or sufficiently large to include home ranges of free-roaming and wild mammals. The advice of wild animal management experts should be sought where the involvement of wild animals is suspected to ensure that the boundaries of the RA take into consideration the movements of wild animals. Close liaison with community leaders will be required where remote Indigenous communities are at risk and populations of free-roaming animals are involved. The relationship between affected remote communities, their outstations and hunting grounds (etc), and other communities with which they have strong family ties may also need to be considered.

The location of geographic features (eg water bodies) that may limit the distribution of maintenance host species, and the location of shire or local government area boundaries should also be taken into consideration when determining the extent of an RA.

5.1.2 Control area (CA)

In the response to RABV, a CA may be declared to provide a buffer zone between the RA and the noninfected (outside) area. The factors influencing the boundaries of the RA should also be considered in determining the boundaries of a CA.

5.2 Other areas

Not applicable.

5.3 Premises classifications

Detailed guidelines for classifying premises statuses are provided in the **AUSVETPLAN guidance document *Declared areas and application of premises classifications in an emergency animal disease response***, and the definitions are in the Glossary.

The premises status classifications to be used in the response to an incident in Australia of rabies due to RABV are outlined below.

The application of individual premises classifications may be more challenging in situations where free-roaming animal populations are involved (as in many remote Indigenous communities). In such circumstances, close liaison with community leaders will be required.

5.3.1 Premises status classifications

For RABV, the premises classifications to be used are:

- infected premises (IP)
- suspect premises (SP)
- trace premises (TP)
- dangerous contact premises (DCP)
- dangerous contact processing facility (DCPF)
- approved processing facility (APF)
- approved disposal site (ADS)
- at-risk premises (ARP)
- premises of relevance (POR)
- resolved premises (RP)
- unknown status premises (UP)
- zero susceptible species premises (ZP).

In the response to RABV, the DCP classification will include:

- all premises with mammals that a case may have contacted or visited (irrespective of proximity to the linked IP)
- if a case was known to roam, premises of other canids within the case's roaming range.

If carnivores in the RA are known to be confined to a premises, with little or no opportunity for contact with confirmed cases or potentially exposed animals, the premises could be considered an ARP.

The classification of premises in an RA with noncarnivore mammals (eg livestock) will require individual assessment, taking into consideration the species, the likely source of RABV, the presence of wild or free-roaming carnivores, and the potential epidemiological links to a case.

5.3.2 Qualifiers

The following qualifying categories may be added to a property status:

- assessed negative (AN)
- vaccinated (VN).

5.3.3 Other disease-specific classifications

Not applicable.

5.4 Reclassifying premises and previously declared areas

Maintaining movement restrictions on areas for long periods has important implications for resource management, animal welfare, business continuity, and socioeconomic impacts on producers and regional communities. Therefore, attention should be given to reclassifying premises and previously declared areas as quickly as possible.

Detailed guidelines for reclassifying previously declared areas are provided in the **AUSVETPLAN guidance document *Declared areas and application of premises classifications in an emergency animal disease response***.

For rabies due to RABV, the key principles for reclassifying a previously declared area to one of a lower risk status include the following:

- The area should be epidemiologically distinct from other declared areas.
- All TPs and SPs have been investigated and reclassified, and all IPs, DCPs and DCPFs in the area have been reclassified as RPs.
- All tracing and surveillance associated with emergency animal disease control has been completed satisfactorily, with no evidence or suspicion of infection in the area.
- An approved surveillance program has confirmed no evidence of infection in the RA.

Factors that may influence the recommended minimum period that should elapse before reclassification of the area since predetermined disease control activities and risk assessment were completed on the last IP or DCP in the area include:

- completion of the vaccination program in the area (if used)
- confidence that ongoing surveillance is adequate to detect any future potential cases
- presence of wild maintenance host species in the area.

6

Movement controls

6.1 Principles of movement controls

General principles for movement controls for managing emergency animal diseases are provided in the **AUSVETPLAN guidance document *Movement controls***.

6.2 Recommended movement controls

General permits (GPs) and special permits (SpPs) may not be available until the relevant chief veterinary officer gives approval for movements, and this approval not be given in the early stages of a response.

SpPs are used for higher-risk movements. They require formal application and individual risk assessment by the relevant government veterinarian or gazetted inspector of stock. An SpP may only be issued if the assessed risk can be managed by applying acceptable mitigation measures.

The recommended movement controls in the response to rabies lyssavirus (RABV) are outlined below.

6.2.1 Live susceptible animals

Maintenance host species

Within restricted areas (RAs), the movement of maintenance host species (eg dogs) should be restricted to limit contact with other mammals and people. This will reduce the likelihood of maintenance host species becoming exposed to infection with RABV or, if they are already incubating RABV, reduce the likelihood that they will infect other animals and people.

The movement restrictions applied may vary with the local context of the relevant maintenance host species. Guidance on managing the movement of wild (and free-roaming) mammals is provided in Section 4.3.14.

For example, for dogs in urban areas, the restrictions might include confinement of dogs to owners' premises. Euthanasia of dogs found roaming and unclaimed within a certain time period may apply. In contrast, in remote communities with owned but free-roaming dog populations, alternative means of limiting dispersal, and the exposure of other animals and people may need to be implemented. These should be developed in close consultation with the relevant community, considering the ownership and role of these animals in the community (eg use in hunting for food).

Movement of maintenance host species within or outside the RA is prohibited except under SpP, subject to risk assessment on a case-by-case basis. A permit would only be granted if the animal has

completed an RABV vaccination course and shows evidence of an adequate immune response (eg by serological monitoring).

For maintenance host species in the control area (CA), movements into the RA are prohibited except under SpP. Applications for SpPs will be considered case by case, subject to risk assessment. A permit would only be granted if the animal has completed an RABV vaccination course and shows evidence of an adequate immune response (eg by serological monitoring).

Decisions on movement controls for maintenance host species within the CA or from the CA to the outside area (OA) should be made in the context of the incident. It may be desirable for such movements to be subject to a GP (eg to aid traceability); however, it may be difficult to monitor compliance (especially where the CA is large).

For maintenance host species in the OA, movements into the RA or the CA are prohibited except under SpP. Applications for SpPs will be considered case by case basis, subject to risk assessment. A permit would only be granted if the animal has completed an RABV vaccination course and shows evidence of an adequate immune response (eg by serological monitoring).

No movement controls will apply to the movement of maintenance host species within the OA.

Other mammals (spillover host species)

Movement controls will not apply to asymptomatic spillover host species in either declared areas or the OA.

Spillover host species showing clinical signs consistent with rabies are prohibited from moving except under SpP for destruction, sampling and disposal, where these activities cannot be safely performed on the premises of origin.

6.2.2 Carcasses

Carcasses of animals confirmed or suspected as being infected with RABV should be disposed of in a biosecure manner (see Section 4.3.12). For small animals, this may be managed through biohazard waste management arrangements without the need for specific movement permits. For larger animals or large numbers of carcasses, or where local biosecure disposal is not feasible, movement under SpP to an approved disposal site may be required, under the following conditions:

- Movement is to an approved disposal site only.
- The waste material is transported in a biosecure manner (that prevents leakage of materials from the transport vehicle).
- The waste material is not brought into direct or indirect contact with susceptible animals.
- All people having direct contact with carcasses of animals confirmed or suspected as being infected with RABV have current RABV vaccination and wear appropriate personal protective equipment (PPE) (see Section 4.3.5).
- All other people involved in the transport and disposal of the waste material wear appropriate PPE (see Section 4.3.5).
- The vehicle and all equipment that has had contact with the waste material are cleaned and disinfected following transport.
- The permit accompanies the waste material being transported.



Holstein-Friesian cows grazing near Moss Vale, New South Wales, Australia.

6.2.3 Semen and embryos from live susceptible animals

Movement controls are not required. There is no evidence of transmission of lyssaviruses in animals through semen and embryos.

6.2.4 Meat and meat products

Meat and meat products from animals showing clinical signs of rabies must not enter the human or animal food chain. Controls to restrict the movement of rabid animals to slaughter (and processing) are provided in Section 6.2.1.

No restrictions will apply to meat and meat products derived from asymptomatic animals on the premises.

6.2.5 Milk and dairy products

Milk collected from animals showing clinical signs of rabies should not enter the human or animal food chain but should be disposed of in a biosecure manner (see Section 4.3.12).

Where possible, milk obtained from animals within the 14 days before the onset of clinical signs until the time of death, and milk products derived from milk collected within this timeframe should not enter the human or animal food chain but should be disposed of in a biosecure manner (see Section 4.3.12).

The tracing of fresh milk is only necessary to the point at which it is established that the milk has been pasteurised.

No restrictions will apply to milk and milk products collected from asymptomatic animals on the premises.

6.2.6 Eggs and egg products

Not relevant.

6.2.7 Hides, skin, wool and other fibres

Movement controls are not required. Hides, skins, wool and other fibres are not implicated in the natural transmission of RABV.

6.2.8 Other animal byproducts

Other animal byproducts from animals confirmed or suspected to be infected with RABV should not enter the human food chain or be used to produce biological products (eg vaccines, therapeutics). Following risk assessment, the movement of such products to either an approved disposal site (ADS) or a processing facility approved for that use may be permitted, subject to appropriate conditions to mitigate the identified risks.

6.2.9 Waste products and effluent

Waste products contaminated with saliva or neural tissues from infected animals should be disposed of in a biosecure manner. For small volumes, disposal may be managed through biohazard waste management arrangements (without the need for specific movement permits). For larger volumes, movement of the contaminated material should be managed as for carcasses (see Section 6.2.2).

Blood, faeces and urine from potentially infected animals are not considered to pose a risk of exposure to RABV, and no restrictions are required on waste products and effluent containing or contaminated with these items.

6.2.10 Vehicles, including empty livestock transport vehicles and associated equipment

Vehicles and equipment involved in the transport of animals that are suspected of being infected with RABV should be cleaned and disinfected following transport of the animals (and before transport of other animals) to remove any contamination with saliva or neural tissues. This requirement is captured in the permit conditions for the movement of live animals (see Section 6.2.1).

No other restrictions apply to the movement of empty livestock transport vehicles and associated equipment.

6.2.11 Nonsusceptible animals

The movement of animals other than mammals is not considered to pose a risk of RABV transmission. The movement of live mammals is discussed in Section 6.2.1.

6.2.12 People

People involved in handling potentially infected animals, or items contaminated with saliva or neural tissues from potentially infected animals should have current RABV vaccination and wear appropriate personal protective equipment (PPE). They should wash any potentially contaminated areas of the body after removing the PPE (see Section 4.3.5).

6.2.13 Specimens

Specimens should be collected according to Section 2.5.4. They should be packed and transported according to International Air Transport Association guidelines.

6.2.14 Crops, grains, hay, silage and mixed feeds

Movement restrictions are not required. Crops, grains, hay, silage and mixed feeds are not implicated in the transmission of RABV.

6.2.15 Equipment, including personal items

Equipment, including personal items such as footwear and clothing, that may be contaminated with saliva or neural tissue from potentially infected animals should be cleaned and decontaminated or disposed of (see Section 6.2.2).

6.2.16 Sales, shows and other events

In the RA, events such as sales and shows for carnivores are prohibited until the vaccination program is complete in the area. Sales and shows for carnivores may proceed in the CA at the discretion of the relevant jurisdictional chief veterinary officer (CVO).

Sales and shows for other mammalian species may proceed in declared areas at the discretion of the relevant jurisdictional CVO.

Decisions on events will be based on risk assessment, taking into consideration the RABV variant and maintenance hosts involved in the incident, and the potential involvement of wild or free-roaming mammals in the incident (including their presence, density and distribution in relation to the location of the planned event). The RABV vaccination status of mammals attending the event may also need to be considered. People movements for such sales, shows and events should be in accordance with Section 6.2.12.

6.2.17 Stock routes and rights of way

Access to stock routes and rights of way in declared areas will be at the discretion of the relevant jurisdictional CVO. Decisions on access will be based on risk assessment, taking into consideration the potential involvement of wild or free-roaming mammals in the disease event, and their presence, density and distribution in relation to the stock routes and rights of way.

6.2.18 Animal movements for emergency (including welfare) reasons

Permission for the movement of mammals for emergency (including welfare) reasons will be based on risk assessment on a case-by-case basis and subject to appropriate conditions to mitigate the identified risks.

6.2.19 Other movements

Permission for other movements will be based on risk assessment on a case-by-case basis and subject to appropriate conditions to mitigate the identified risks.

7

Surveillance and proof of freedom

7.1 Surveillance

The key objectives and priorities for surveillance in response to an outbreak of Japanese encephalitis (JE) are outlined in [Section 4.3.3](#).

7.1.1 Specific considerations

Specific considerations for surveillance for rabies lyssavirus (RABV) include the following:

- Because there is no reliable method for excluding RABV infection in live animals, surveillance will rely on detection and reporting of clinical signs and behavioural changes consistent with rabies in animals, and of potential exposures of people and animals.
- Any mammal showing a change in behaviour should be given a suspect status.
- Widespread destruction of animals to obtain surveillance samples is undesirable and counterproductive, and risks compromising the response (see [Section 4.3.11](#)).
- During an outbreak, all human exposures in the restricted area(s) (RA(s)) must be reported to human health authorities to allow risk assessment of the person; and tracing, seizure, detention or destruction of the animal involved (as part of integrated bite case management).
- Surveillance in mammals will target the maintenance host species involved in the outbreak.
- Any species involved in spillover infection from the maintenance host species will be the next priority for surveillance (over other potential spillover host species).
- For domestic animals, surveillance may involve visiting and mapping properties, and determining population densities in the RA(s).
- Vaccination of asymptomatic animals during surveillance visits may encourage owner participation in surveillance programs (see [Section 4.3.8](#)).
- Animal owners and members of the public should be encouraged and assisted to report
 - any animal bite incidents, including details of the offending animal
 - any unusual behaviour, illness or death in domestic or wild animals
 - any possible early signs in animals, as well as any possible cases from the past.
- Veterinary reports of animal exposures to animals suspected of being infected will be investigated.
- Surveillance in wild and free-roaming mammals may be required.

Guidance on appropriate management of non-bat mammals under investigation for RABV is provided in [Section 4.3](#).

7.1.2 Premises surveillance

Surveillance on premises of different classifications will be guided by the considerations above and the guidance on the management of non-bat mammals under investigation for RABV (Section 4.3).

Surveillance for RABV in wild and free-roaming animals

A surveillance program may need to be developed for surveillance of wild and free-roaming mammals. Wild animal experts must be engaged in planning of monitoring and surveillance programs. The initial concern is to identify the respective hosts associated with the specific viral variant – this will inform movement controls, vaccination strategies and surveillance.

Surveillance of wild and free-roaming mammals may involve spotlight, ground or aerial surveys, with capture or destruction of any animals exhibiting abnormal behaviour, and collection of dead animals for laboratory examination. Because disease due to lyssaviruses is fatal within days of clinical onset, the number of detectably affected animals in a wild or free-roaming population is always low. The best animals to acquire for testing are those that have recently died or become sick. Engagement with remote community members to report any abnormalities observed during time spent on-country may assist with this surveillance.

Guidelines for wild animal surveillance are further discussed in the **AUSVETPLAN operational procedures manual *Wild animal response strategy*** [to be updated].

7.2 Proof of freedom

Providing evidence of freedom from RABV following an outbreak will be particularly important for public health and social amenity. Evidence to support a later declaration of freedom should be collected throughout the response. The World Organisation for Animal Health (OIE) recommendations for duration of surveillance before a declaration of freedom can be made are provided in Chapter 8.14 of the OIE *Terrestrial animal health code*.

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Appendix 1

LYSSAVIRUS FACT SHEET

Disease and cause

Rabies and disease due to Australian bat lyssavirus (ABLV) are caused by infection with viruses of the genus *Lyssavirus*, family *Rhabdoviridae*.

Occurrence in Australia

Rabies lyssavirus (RABV) does not occur in Australia, but ABLV has a wide geographical distribution in bats in Australia.

Species affected

Lyssaviruses can infect most (if not all) warm-blooded terrestrial animals (mammals).

Key signs

Early signs of lyssavirus infection in domestic animals are generally nonspecific, and may include excessive physical sensitivity at the wound site and a temporary rise in temperature. In livestock, this may be associated with a drop in production (eg of milk).

Other common signs include restlessness, muscle tremors, changes in appetite (increased or decreased), vomiting, diarrhoea, pupillary dilation, hyperreactivity to stimuli, sexual excitement, unusual vocalisation, dysphagia and increased salivation. Some animals may become withdrawn and fearful, whereas others display increased aggression.

The clinical signs of rabies in wild animals are highly variable and consistent with those seen in domestic animals. An important common feature in wild animals is the loss of normal shyness and fear of people. This makes such animals particularly dangerous to children, who may wrongly interpret this behaviour as indicating friendliness.

Death usually occurs within 10 days of the onset of clinical signs.

Spread

The lyssavirus lifecycle involves both maintenance and spillover host species. Although lyssaviruses can infect most (if not all) warm-blooded terrestrial animals (mammals), only a limited range of species can act as maintenance hosts. Spread is primarily via a bite or scratch from an infected animal.

Persistence of the agent

Lyssavirus is comparatively fragile and does not survive for long periods outside the host.

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Appendix 2

TRANSMISSION OF AUSTRALIAN BAT LYSSAVIRUS IN AUSTRALIAN BAT POPULATIONS

Species susceptibility

Australian bat lyssavirus (ABLV) infection has been found in a number of megabat and microbat species,⁴³ and all Australian bat species are considered susceptible.

ABLV infection is found in four common species of flying fox (megabats) that occur in mainland Australia:

- black flying fox (*Pteropus alecto*)
- little red flying fox (*P. scapulatus*)
- grey-headed flying fox (*P. poliocephalus*)
- spectacled flying fox (*P. conspicillatus*).

ABLV infection has been found in one species of microbat, the yellow-bellied sheath-tailed (YBST) bat (*Saccolaimus flaviventris*). Serological evidence of exposure to ABLV has been reported in nine genera, representing five of the six families of Australian microbats (Field 2018, Prada et al 2019):

- *Chaerephon* and *Austronomus* (Molossidae)
- *Chalinolobus*, *Vespadelus*, *Falsistrellus* and *Nyctophilus* (Vespertilionidae)
- *Hipposideros* (Hipposideridae)
- *Macroderma* (Megadermatidae)
- *Saccolaimus* (Emballonuridae).

For a guide to identification of Australian bat species, refer to the Field companion to the mammals of Australia (Van Dyck et al 2013).

Prevalence

National data suggest that ABLV prevalence in Australian bats is extremely low. Surveys have indicated a prevalence of ABLV infection in the wild bat population of less than 1% (Field 2005). This is consistent with findings from the United States, Mexico and the Philippines for other lyssavirus biotypes in bats (Steece & Altenbach 1989, Arguin et al 2002).

⁴³ In this manual, the term 'megabat' is used to refer to flying foxes, tube-nosed bats and blossom bats; 'microbat' is used for insectivorous species.

ABLV infection is more common in sick, injured and orphaned bats, especially those with neurological signs (Barrett 2004). Nationally collated data show that the prevalence of ABLV infection in bats submitted for testing⁴⁴ between 2010 and 2018 ranged between 2.8% and 7.4%.⁴⁵

Factors affecting transmission

The ecology of bats may have a major influence on the persistence and transmission of lyssaviruses. Seroprevalence in bats submitted for testing varies with species: it is lower in microbats (up to 5%) than in megabats (up to 20%) (Barrett 2004, Field 2005). Differences in seroprevalence and probability of exposure within these groupings have also been noted.

Megabats

All species of *Pteropus* lead a communal life, spending the day hanging by their hind feet upside down in the upper branches of trees. Bat colonies (known as camps) often number tens of thousands or even hundreds of thousands of bats. At dusk, the bats fly over well-established flyways in search of fruit and flowering trees. In contrast, the YBST bat, a microbat, tends to roost in groups of 2–6 and occasionally up to 30 (Churchill 2008).

In one study, mature flying foxes were found to be twice as likely as immature flying foxes to be ABLV-positive using a fluorescent antibody test (Field 2005). Age is commonly a risk factor for horizontally transmitted infectious diseases that provoke a persistent antibody response (Mills & Childs 1998), since older animals have had a longer opportunity for exposure and infection.

The effect of season on the transmission of ABLV in different flying fox species is incompletely understood. Some studies have suggested a higher probability of ABLV transmission in late pregnancy in little red flying foxes (first quarter of the year) and with mating times in other species (second quarter of the year) (Field 2005). The little red flying fox is a highly mobile species, and large coalesced populations periodically make major movements in pursuit of preferred food trees (Hall & Richards 2000). They typically swell camp numbers from thousands to tens or hundreds of thousands, with a resultant increase in density and physical interaction. The prevalence of ABLV infection could reflect seasonal nomadic movements of the little red flying fox (Field 2005).

In flying foxes, species also appears to be an important risk factor for infection (Field 2005). Of the four species common in Australia (*P. scapulatus*, *P. poliocephalus*, *P. alecto* and *P. conspicillatus*), *P. scapulatus* has the highest prevalence of infection. The biology of *P. scapulatus* differs significantly from that of the other mainland species, supporting a hypothesis that host or environmental factors might be responsible for the higher prevalence. For example, the roosting density (and therefore frequency of direct physical contact) of *P. scapulatus* is much greater than for other species (Hall & Richards 2000). *P. scapulatus* also makes much larger nomadic movements than the other species, potentially increasing the opportunity for exposure (Hall & Richards 2000). Finally, the reproductive cycle of *P. scapulatus*, although similar to other *Pteropus* species, is out of phase by 6 months relative to other species (Hall & Richards 2000).

Microbats

Species appears to be the only known risk factor for infection in microbats (Field 2005). The prevalence of antibodies (62.5% reported in Field (2005)) indicates that rates of infection are higher in the YBST bat than in other insectivorous species, suggesting that this species may play an

⁴⁴ Bats are submitted for ABLV testing for various reasons, including bat-human or bat-pet contact (eg bites, scratches), neurological signs or unusual behaviour, and bats found dead or euthanased as a result of trauma. Nationally collated data are held by Wildlife Health Australia and published regularly in ABLV Bat Stats (www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx).

⁴⁵ Figures collated by Wildlife Health Australia and provided by CSIRO-AAHL, Barrett (2004) (with permission), Queensland Health, Wildlife Health Australia subscribers, zoo veterinarians, and state/territory wildlife health coordinators.

important role in the epidemiology of ABLV. Limited molecular studies have demonstrated an ABLV variant in the YBST bat distinct from that in flying foxes (Gould et al 2002, Guyatt et al 2003, Barrett 2004). The absence of isolates or antigenic material from other microbat species precludes further comparison.

Steece and Altenbach (1989) described an association between the postnatal period and the incidence of rabies infection in the Mexican free-tailed bat (*Tadarida brasiliensis*). Perez-Jorda et al (1995) reported seasonal variation in antibody titres to European bat lyssavirus 1 (EBLV-1) in a colony of *Eptesicus serotinus*, another microbat species (with seroprevalence falling from a maximum of 74% in spring to less than 10% in summer), but did not describe the variation in terms of the stages of the bat's reproductive cycle (Field 2005). A subsequent longitudinal survey on two serotine bat colonies in northeast France by Robardet et al (2017) using capture–recapture methodology confirmed peak EBLV-1 seroprevalence estimates of 34% and 74% and an oscillation period of 2–3 years at the two study sites over a 7-year period. This study also found that seropositivity did not affect the survival ability of individuals, supporting the notion that particular bat species have developed adaptive mechanisms (as yet uncharacterised) to handle lyssavirus exposure with minimal population impacts.

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Appendix 3

MANAGEMENT OF AUSTRALIAN BAT LYSSAVIRUS RISK IN BATS IN CAPTIVITY OR CARE

Captive populations of bats are present in zoos and wildlife sanctuaries in Australia. Housing varies from double-mesh 'off exhibit' enclosures (away from public access) to large, walk-through enclosures with public access.

In addition, there is an extensive wildlife carer network throughout Australia that provides temporary care for sick, injured and orphaned bats destined for rehabilitation, and houses recovered bats that are not suitable for release. Bat carers play an important role in rehabilitating bats, educating the public about bats, reporting possible cases of Australian bat lyssavirus (ABLV) infection and other diseases in bats, and reporting potential human and domestic animal exposures. Unlike the general public, bat carers are rabies vaccinated to help prevent development of clinical disease due to ABLV. By rescuing sick and injured bats, they reduce the risk to the general public who might otherwise attempt to rescue bats themselves.

Bats in care are kept under a range of conditions in carers' homes or backyards. A few carers maintain permanent or semipermanent colonies in large outdoor enclosures. Established rehabilitation centres may house hundreds of sick or orphaned bats at one time. Some of these centres allow visitor access for education purposes.

Suitable individual bats may be used as 'outreach' animals for the purpose of education. For example, bat conservation or rehabilitation groups may take a bat to educational talks and events, and zoos and wildlife sanctuaries may use bats for keeper talks to visitors. These are an important way of educating the public and encouraging interest in, and support for, conservation of bat species.

Prevention of ABLV in captive bat colonies

Biosecurity is key to preventing introduction and spread of ABLV within a captive bat colony. Preventing contact between wild bats and captive bats will greatly reduce the chance of introduction of ABLV. Measures include building outdoor enclosures that exclude contact with wild bats (eg double mesh) and quarantine of incoming bats (or 'all-in-all-out' management, where practicable).

As far as practicable, wild bats first entering care or joining a captive colony should be held in isolation for at least 3 days after arrival and observed closely for any clinical signs suggestive of ABLV infection.⁴⁶ If any such signs are noted, the isolation period should be extended to 10 days. Where it is not feasible to isolate individual bats, they may be kept in small groups to reduce the number of in-contact bats if a bat is infected with ABLV. See below for advice on management of a suspect ABLV-infected bat.

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www.qld.gov.au/environment/plants-animals/wildlife/bats-gbo

Regardless of biosecurity measures, all bats should be considered as potentially infected for risk management purposes.

Pre-exposure rabies vaccination (not currently available) could be a useful tool in a long-term captive colony for reducing the risk of ABLV in bats, and therefore the risk to staff, volunteers and the public. However, vaccination of animals with rabies lyssavirus (RABV) vaccine before exposure to ABLV (pre-exposure prophylaxis) is only allowed under relevant permits from the Australian Pesticides and Veterinary Medicines Authority.⁴⁷ As well, the level and duration of protection provided to bats by vaccination, and the effect of vaccination on any pre-existing ABLV infections in the colony are not known. RABV vaccination of wild bats coming into temporary captive care (eg for rehabilitation by wildlife carers or veterinary treatment) is unlikely to reduce risk to people because of the timeframes involved.

Management of ABLV risk to humans from captive bat populations

Staff and volunteers

Education, training and vaccination are all critical to managing people working with captive bat populations. All staff and volunteers who handle, or come into contact with, bats in a captive colony or in care should receive the full course of RABV vaccination and have evidence of current immunity (as described in ATAGI (2018)), be trained in bat handling, be educated about ABLV, and wear appropriate personal protective equipment (PPE).

Members of the public

Organisations housing captive colonies of bats should do a risk assessment and develop risk mitigation measures (eg physical separation or signage) to prevent direct contact between visitors and bats. Bats should only be housed in walk-through enclosures where the risk to people has been minimised – for example, a closed colony in a double-mesh enclosure that is designed to reduce the likelihood of contact between the bats and the visitors, such as providing roosting locations away from visitor pathways. For bats used for education and outreach programs, measures include selecting bats with appropriate temperament, using suitable transport containers, preventing any direct contact between the bat and members of the public, and having additional trained handlers in attendance.

If a person is bitten or scratched, or has other potentially infectious contact (saliva contamination of mucous membranes or broken skin), immediately perform first aid as described in Section 4.2 and seek urgent medical advice. Each organisation should develop protocols for response to an incident. Organisations housing captive bats should also create a record of any exposure and document the circumstances surrounding this event.

Protecting the public, staff and volunteers will also protect the bat, as there may be a recommendation for the bat to be euthanased for testing when a person is bitten or scratched.

Management of a suspect ABLV-infected bat in captivity (including rehabilitation)

Note: Potentially infected animals should be approached and handled only when necessary and then with extreme caution. They should only be approached by appropriately trained and RABV-vaccinated personnel.

In captive bat colonies, any bat exhibiting clinical signs consistent with ABLV infection should be immediately isolated (if it is safe to do so) and observed. If ABLV is suspected, the bat should be euthanased and tested. Bats that have been in contact with the suspect bat should be isolated from non-exposed bats until the results are available.

⁴⁷ <https://portal.apvma.gov.au/permits>

Neurological signs can occur in bats as a result of trauma and diseases other than ABLV infection. It is legitimate to care for bats with neurological signs, provided that the bat is potentially releasable, the carer is sufficiently experienced to manage the risk, the bat is kept isolated, and appropriate measures are taken to manage human health risk. Where these conditions cannot be met, bats with neurological signs should be euthanased.

Management of bats potentially exposed to a bat that tested positive for ABLV

Any bat that has been in direct contact with a confirmed ABLV-infected bat and exhibits clinical signs or behavioural changes consistent with ABLV infection should be euthanased.

Management of in-contact bats without clinical signs should be decided by a risk-based approach, taking into account the status of the bat. Options include:

- immediate release
- isolate, monitor and potentially vaccinate pending release
- Euthanasia.

Immediate release

Bats that do not otherwise require care may be considered for immediate release. Vaccination before release may be considered on a case-by-case basis.

Isolate, monitor and potentially vaccinate pending release

Bats not suitable for immediate release that require ongoing care should, where possible, be isolated from other bats and monitored for clinical signs or behavioural changes consistent with ABLV infection until ready for release. Post-exposure vaccination of the bats should be considered to reduce risk to carers by decreasing the likelihood that the bat progresses to clinical disease and becomes infectious.

Whether vaccinated or not, potentially exposed bats should be handled as little as possible, and all people who enter an enclosure with the bats should be vaccinated against RABV and wear appropriate PPE.

RABV vaccination of groups of bats in care has occurred in a number of instances and jurisdictions following chief veterinary officer (CVO) approval.⁴⁸ Post-exposure vaccination with RABV vaccine should follow the same protocol as for domestic animals (refer to the Queensland Government information for veterinarians on ABLV⁴⁹) except that vaccinated bats may be released immediately after vaccination if they no longer require care for other reasons. As for other animals, the use of vaccine must be approved by the CVO of the relevant jurisdiction.

The occasional release of a bat that may be incubating ABLV into the wild population (in which ABLV is endemic) is not expected to have a significant impact on the bat population, or the risk to humans or other animals. Release of (vaccinated or unvaccinated) bats has the benefit of avoiding the loss of apparently healthy animals, which in some cases may be threatened species, and maintaining the relationship with the bat carer community, such that reporting of suspect ABLV cases by bat carers continues.

Euthanasia

Euthanasia may be warranted in some situations – for example, when the potential risk to people

⁴⁸ While there are no vaccines registered for use in bats either in Australia or overseas, their use can be authorised by a CVO under a minor use permit issued by the Australian Pesticides and Veterinary Medicines Authority. See <https://portal.apvma.gov.au/permits>

⁴⁹ www.publications.qld.gov.au/dataset/australian-bat-lyssavirus-information-for-veterinarians

cannot be reasonably managed. A decision to euthanase a captive bat to manage ABLV risk should be made in consultation with the relevant environmental agency. Some bat species are threatened, and consideration of alternative arrangements to reasonably manage the risk may be warranted.

Management of captive bats following human exposure

If a person is bitten or scratched by a bat from a captive colony, they should immediately perform first aid and seek urgent medical advice (see Section 4.2). The decision on whether to euthanase the bat for ABLV testing should be made case by case, taking into consideration such aspects as the colony history, quarantine protocols and the nature of the enclosure (potential for contact with wild bats), as well as the RABV vaccination status of the person.

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Appendix 4

MANAGEMENT OF NON-BAT ANIMALS UNDER INVESTIGATION FOR AUSTRALIAN BAT LYSSAVIRUS INFECTION

Note: This guidance focuses on the management of non-bat animals; guidance on the management of Australian bat lyssavirus (ABLV) risk in captive bats is provided in Appendix 3.

Decisions on how to manage non-bat animals under investigation for ABLV infection will be made case by case, informed by risk assessment. This is because:

- infected animals may show a range of clinical signs, and these are not pathognomonic for ABLV infection
- the incubation period may be prolonged
- the infective period of cases is relatively short (presumed to be up to 14 days before the onset of clinical signs), but the time of onset of clinical signs may be unknown
- in many instances, there will be uncertainty about the nature and timing of any contact or possible exposure to confirmed or probable cases of ABLV infection.

Where there are potential risks to human health, the risk assessment should be made jointly by the relevant animal health and public health professionals or agencies.

Non-bat animals showing clinical signs or behavioural changes consistent with ABLV infection

Note: Potentially infected animals should be approached and handled only when necessary and then with extreme caution. They should only be approached by appropriately trained and rabies lyssavirus (RABV)-vaccinated personnel. If it can be done without risk to the operator, every effort should be made to capture and safely confine the animal. If the animal cannot be safely captured or confined, and therefore constitutes a risk to people or other animals, it should be immediately destroyed.

The options for managing non-bat animals showing clinical signs or behavioural changes consistent with ABLV infection are:

- euthanasia and testing
- quarantine and observation for 14 days – it is presumed that animals with clinical disease due to ABLV will show clinical progression to death within this timeframe; if this does not occur, the disease is unlikely to be due to lyssavirus infection and alternative diagnoses may be explored.

The risk assessment to inform decisions on managing non-bat animals showing clinical signs or behavioural changes consistent with ABLV infection should consider:

- the nature and onset of the clinical signs (and so the level of suspicion that these are genuinely signs of ABLV infection)
- the existence and strength of any epidemiological links to confirmed cases of ABLV infection – not all contact with infected animals will result in exposure to ABLV infection, because of either the nature of the contact or its timing (eg if not within the expected period in which an infected animal was infective)
- the resources available for quarantine and observation of animals – because ABLV-infected animals pose a public health risk, quarantine should be in secure facilities that mitigate this risk
- community support for the response options – if owners or carers believe that their animals will be destroyed if they report any possible signs of ABLV infection, irrespective of whether the animal is genuinely infected, this may result in failure to report possible cases, and undermining of disease control efforts and other initiatives.

Non-bat animals showing clinical signs or behavioural changes consistent with ABLV infection and with known exposure to a confirmed case (likely to be within its infective period) are highly likely to be infected (probable cases) and should be destroyed and tested.

In determining how to manage all non-bat animals under investigation for ABLV infection, the risk to public health will have an overriding influence on decision making; where this risk cannot be adequately managed, the animal should be destroyed and tested.

Asymptomatic non-bat animals that may have been exposed or potentially exposed to bats that are, or could be, infected with ABLV

Note: This guidance relates to exposure of non-bat animals to bats that are, or could be, infected with ABLV. It differs from the guidance provided for management of animals potentially exposed to RABV because ABLV is not known to establish transmission cycles in non-bat animals, and there has been no demonstrated transmission of ABLV from asymptomatic non-bat animals to other animals or humans. Should ABLV establish transmission cycles in non-bat animals, the guidance for RABV infection (rabies) should be used instead.

Determining the ABLV status of the bat

The ABLV status of any bat having direct contact with domestic animals (particularly dogs, cats and horses – species that often have close contact with people and so pose a public health risk) or captive wildlife will be determined if the bat is available for testing.

If the bat is alive and free from any clinical signs or behavioural changes suggestive of ABLV infection, and deemed suitable for rehabilitation and release, it may instead be monitored for 14 days for signs consistent with ABLV infection. If the bat does not show any clinical signs or behavioural changes consistent with ABLV infection during this period, it is unlikely to have been infectious when the potential exposure of the domestic animal occurred. Because the period of preclinical shedding of ABLV in infected bats is not known, a definitive assessment of the bat's ABLV status cannot be made from this monitoring, but it will inform the risk assessment for managing the potentially exposed animal.

Management options

If an animal has potential or known contact with a bat confirmed to be ABLV-negative, it can be assumed that no exposure has occurred from that contact, and no further management would be required.

Management of all cases in which a domestic animal may have had contact with a bat that is ABLV-positive or of unknown status (eg not available for testing) will be based on risk assessment. Where there are potential risks to human health, the risk assessment should be made jointly by the relevant animal health and public health professionals or agencies. The risk assessment should consider:

- the likelihood, nature and extent of the exposure of the animal to the bat
- the likelihood that the bat may be infected (see 'Determining the ABLV status of the bat', above)
- the potential exposure of people or other animals if the animal is infected with ABLV
- the owner's likely compliance with any recommendations to isolate the animal and minimise its contact with humans and other animals
- the level of confidence that any potential signs of ABLV infection will be observed and promptly reported.

The risk assessment will be used to provide the animal's owner with advice to allow them to make an informed decision on how to manage their animal. The key management options are as follows:

- Post-exposure RABV vaccination and monitoring. It takes time for the immune system to respond to the vaccine and provide confidence that clinical disease will not develop as a result of the exposure. If this option is chosen, owners should be advised to
 - limit contact with the exposed animal until 28 days following vaccination (to allow time for the immune response). Contact of skin or mucous membranes with saliva from an infected animal – for example, through a wound, or from a bite or scratch – is considered to pose the highest risk of lyssavirus transmission and should be avoided
 - observe the exposed animal closely for 60 days following vaccination (the period when it is most likely that disease will develop from the exposure) and urgently seek veterinary advice if the animal becomes ill or exhibits behavioural changes.

In determining how to manage all non-bat animals under investigation for ABLV infection, the risk to public health will have an overriding influence on decision making.

A5

Appendix 5

KEY COMMUNICATION MESSAGES FOR DOG-MEDIATED RABIES

Note: Key communication messages are presented in **bold** font.

These messages should be adapted to the target audience, as appropriate to the incident. Particular considerations for communicating with remote northern Australian Indigenous communities include the following:

- Messages should be incorporated in a ready-to-go in-language video or other appropriate media.
- Community leaders and key stakeholders should be consulted to adapt the language used in messages.
- Messages used should be jointly agreed with local community leaders, relevant local stakeholders, medical practitioners, animal control and local government officers, and veterinarians.
- The effectiveness of media and communication messages should be tested before broad use.
- Community leaders or trusted community members, such as rangers, environmental health workers or other relevant stakeholders, are likely to be best placed to convey messages.

A case of rabies has been diagnosed in the area.

- Rabies is a fatal disease in people and animals.
- It is mainly spread when an infected dog bites people, or other dogs or animals.
- An animal may take weeks (or months) to show signs of disease after being bitten by an infected dog.
- Once an animal shows signs of rabies, it will die within 10 days.
- There is no cure for rabies in humans or animals once symptoms have appeared.
- Dogs and dingoes are the most important animals for spreading rabies.
- Cats, foxes and any other mammal can also infect another animal or human.
- People who are bitten, or licked on a wound, by an infected dog (or cat or other animal) can get the disease.
- Beware of any abnormally friendly wild mammals. In other countries, wild animals infected with rabies have become unusually docile.

Immediately report any suspicious animals to HOTLINE NUMBER.

- It is important for communities to understand the signs of rabies.
- Behaviour changes are often the first sign of rabies (see below for signs).
- Early reporting of suspect dogs reduces the chance of people and dogs being bitten.
- Do not approach or handle an animal with abnormal behaviour.
- Only people who are vaccinated against rabies, trained, and wearing protective equipment and clothing should try to handle a potentially infected animal.
- A dog with rabies will die. It is better to have a suspect animal euthanased or put into quarantine than allow it to roam around the community and potentially spread the disease.

Immediately report any cases of people bitten by an animal to medical staff, or the relevant state or territory human health authorities.

- If people are treated by a doctor immediately after exposure to an infected animal, the disease can usually be prevented.

If there is a bite or exposure to saliva from a dog, cat or other animal, wash the wound or area immediately with soap and water for 15 minutes, then apply suitable antiseptic. If soap or antiseptic is not available, wash thoroughly with plain water. After washing, immediately report to a public health authority for urgent medical treatment and advice.

Signs of rabies in dogs

- **Change in behaviour**
- **Bites other animals or humans**
- **Death within 10 days of showing first signs**

Change in behaviour may include:

- change in vocalisations (howling)
- pica (chewing objects other than food)
- hypersalivation (drooling)
- restlessness, wandering aimlessly
- hypersexuality (increased sexual behaviour)
- 'fly biting'
- 'bone in throat' syndrome
- aggression
- incoordination, staggering
- paralysis
- convulsions (fitting).

Signs of rabies in cats

- **Change in behaviour**
- **Bites other animals or humans**
- **Death within 10 days of showing first signs**

Change in behaviour may include:

- shy, withdrawn and hiding
- extreme aggression
- increased vocalisation
- hypersalivation (drooling)
- dilated pupils
- paralysis.

Signs of rabies in other animals

- **Change in behaviour**
- **Death generally within 10 days of showing first signs**

Change in behaviour may include:

- restlessness
- wild animals becoming excessively docile and friendly
- aggression
- 'choking' – as if something is stuck in the throat
- paralysis.

To control rabies we need to do the following.

- **Recognise behaviour of rabies in infected dogs and report it.**
 - **Report immediately to authorities or medical staff if:**
 - » **you or anyone else is, or has been, bitten by a dog or cat**
 - » **you notice a dog, cat or other animal behaving abnormally**
 - » **a dog bites another dog**
 - » **a dog or cat has died quite quickly without a known cause.**
 - Include the identity and whereabouts of the animal, if known.
- **Vaccinate all dogs properly, especially puppies and outside dogs.**
 - Vaccination of all dogs is the only proven method of eradicating rabies.
 - All dogs must be vaccinated – owned dogs, stray dogs, and puppies.
 - Vaccinating stray and roaming dogs is key to rabies control because they have a high rate of contact with people and other animals.
 - Vaccinated, healthy dogs protect you from rabies.
 - High herd immunity will stop rabies from spreading and will eventually eradicate the disease.
 - The [IDENTIFICATION] tells us that the dog has been vaccinated.
 - A dog with [IDENTIFICATION] is working for you and should be kept alive.
- **Stop the movement of dogs while we control the disease.**
 - Make sure no dogs move out of the region.
 - Both healthy looking and sick dogs can carry the disease into a new area.
 - Dogs may not be permitted to move or leave your area.
 - You may be requested to keep your dog at home.

- Stray animals may need to be controlled.
- Vaccinated dogs with immunity to rabies may be permitted to move in some cases.
- **Isolate or euthanase dogs (or other animals) that show signs of rabies or are highly likely to have been infected.**
 - Animals with rabies are a danger to people.
 - An animal infected with rabies will die.
 - There is no treatment once an animal shows signs of rabies.

Urgent tracing will be carried out of possibly infected or suspect animals, as well as of people or animals that may have been exposed to them.

Report if you know any possible overseas connection of this case.

Glossary

Disease-specific terms

Confirmed case	A laboratory-confirmed lyssavirus-positive animal.
Dead-end host	An infected animal that does not transmit the pathogen to susceptible hosts.
Immunoglobulin	Antibody proteins.
- IgG	The main form of antibody produced in response to an antigen. Mainly found in body fluids.
- IgM	High molecular-weight antibodies that are the first to be synthesised and released in response to a primary antigenic stimulation.
Infected animal	A live animal that develops clinical signs consistent with the disease and is known to have an epidemiological link (eg in a known infected area or area of epidemiological interest).
Maintenance host	The species that principally sustains the virus cycle; it is highly susceptible to a particular viral variant but less susceptible to other variants. Successful control of rabies in the maintenance host will lead to eradication of the virus cycle in the ecological community.
Negri bodies	Intracytoplasmic inclusion bodies (intracellular structures that are formed by cells in response to viral infection) that are unique to lyssaviruses. They are found mainly in neurons and occur in 50–70% of rabies-infected brains.
Outbreak	The occurrence of one or more cases of a disease or an infection in animals in a common environment.
Prophylactic	Treatment administered prospectively to prevent the onset of disease.

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Rabies	Clinical disease (encephalitis) caused by infection with a lyssavirus.
Spillover host	Infected hosts that belong to a species that do not normally maintain the virus variant in question (eg a host that is not a maintenance host). Note that spillover host is not synonymous with dead-end host, as spillover hosts may transmit infection to other hosts (although such events are relatively uncommon). <i>See also</i> Dead-end host
Strain	Designation for a virus type derived from a single isolate. This definition is usually only applied to laboratory-propagated viruses (eg Pasteur strain).
Variant	A distinct taxonomic entity, as applied to a virus.
Virion	A single particle of a virus.

Standard AUSVETPLAN terms

Animal byproducts	Products of animal origin that are not for consumption but are destined for industrial use (eg hides and skins, fur, wool, hair, feathers, hoofs, bones, fertiliser).
Animal Health Committee	<p>A committee whose members are the chief veterinary officers of the Commonwealth, states and territories, along with representatives from the CSIRO Australian Centre for Disease Preparedness (CSIRO-ACDP) and the Australian Government Department of Agriculture, Water and the Environment. There are also observers from Animal Health Australia, Wildlife Health Australia, and the New Zealand Ministry for Primary Industries. The committee provides advice to the National Biosecurity Committee on animal health matters, focusing on technical issues and regulatory policy.</p> <p>See <i>also</i> National Biosecurity Committee</p>
Animal products	Meat, meat products and other products of animal origin (eg eggs, milk) for human consumption or for use in animal feedstuff.
Approved disposal site	A premises that has zero susceptible livestock and has been approved as a disposal site for animal carcasses, or potentially contaminated animal products, wastes or things.
Approved processing facility	An abattoir, knackery, milk processing plant or other such facility that maintains increased biosecurity standards. Such a facility could have animals or animal products introduced from lower-risk premises under a permit for processing to an approved standard.
At-risk premises	A premises in a restricted area that contains a live susceptible animal(s) but is not considered at the time of classification to be an infected premises, dangerous contact premises, dangerous contact processing facility, suspect premises or trace premises.
Australian Chief Veterinary Officer	<p>The nominated senior veterinarian in the Australian Government Department of Agriculture, Water and the Environment who manages international animal health commitments and the Australian Government's response to an animal disease outbreak.</p> <p>See <i>also</i> Chief veterinary officer</p>

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AUSVETPLAN	Australian Veterinary Emergency Plan. Nationally agreed resources that guide decision making in the response to emergency animal diseases (EADs). It outlines Australia's preferred approach to responding to EADs of national significance, and supports efficient, effective and coherent responses to these diseases.
Carcase	The body of an animal slaughtered for food.
Carcass	The body of an animal that died in the field.
Chief veterinary officer (CVO)	The senior veterinarian of the animal health authority in each jurisdiction (national, state or territory) who has responsibility for animal disease control in that jurisdiction. <i>See also</i> Australian Chief Veterinary Officer
Compartmentalisation	The process of defining, implementing and maintaining one or more disease-free establishments under a common biosecurity management system in accordance with OIE guidelines, based on applied biosecurity measures and surveillance, to facilitate disease control and/or trade.
Compensation	The sum of money paid by government to an owner for livestock or property that are destroyed for the purpose of eradication or prevention of the spread of an emergency animal disease, and livestock that have died of the emergency animal disease. <i>See also</i> Cost-sharing arrangements, Emergency Animal Disease Response Agreement
Consultative Committee on Emergency Animal Diseases (CCEAD)	The key technical coordinating body for animal health emergencies. Members are state and territory chief veterinary officers, representatives of CSIRO-ACDP and the relevant industries, and the Australian Chief Veterinary Officer as chair.
Control area (CA)	A legally declared area where the disease controls, including surveillance and movement controls, applied are of lesser intensity than those in a restricted area (the limits of a control area and the conditions applying to it can be varied during an incident according to need).
Cost-sharing arrangements	Arrangements agreed between governments (national and state/territory) and livestock industries for sharing the costs of emergency animal disease responses. <i>See also</i> Compensation, Emergency Animal Disease Response Agreement

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Dangerous contact animal	A susceptible animal that has been designated as being exposed to other infected animals or potentially infectious products following tracing and epidemiological investigation.
Dangerous contact premises (DCP)	A premises, apart from an abattoir, knackery or milk processing plant (or other such facility) that, after investigation and based on a risk assessment, is considered to contain a susceptible animal(s) not showing clinical signs, but considered highly likely to contain an infected animal(s) and/or contaminated animal products, wastes or things that present an unacceptable risk to the response if the risk is not addressed, and that therefore requires action to address the risk.
Dangerous contact processing facility (DCPF)	An abattoir, knackery, milk processing plant or other such facility that, based on a risk assessment, appears highly likely to have received infected animals, or contaminated animal products, wastes or things, and that requires action to address the risk.
Declared area	A defined tract of land that is subjected to disease control restrictions under emergency animal disease legislation. There are two types of declared areas: restricted area and control area.
Decontamination	Includes all stages of cleaning and disinfection.
Depopulation	The removal of a host population from a particular area to control or prevent the spread of disease.
Destroy (animals)	To kill animals humanely.
Disease agent	A general term for a transmissible organism or other factor that causes an infectious disease.
Disease Watch Hotline	24-hour freecall service for reporting suspected incidences of exotic diseases – 1800 675 888.
Disinfectant	A chemical used to destroy disease agents outside a living animal.
Disinfection	The application, after thorough cleansing, of procedures intended to destroy the infectious or parasitic agents of animal diseases, including zoonoses; applies to premises, vehicles and different objects that may have been directly or indirectly contaminated.
Disinsectisation	The destruction of insect pests, usually with a chemical agent.

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Disposal	Sanitary removal of animal carcasses, animal products, materials and wastes by burial, burning or some other process so as to prevent the spread of disease.
Emergency animal disease	A disease that is (a) exotic to Australia or (b) a variant of an endemic disease or (c) a serious infectious disease of unknown or uncertain cause or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications. <i>See also</i> Endemic animal disease, Exotic animal disease
Emergency Animal Disease Response Agreement	Agreement between the Australian and state/territory governments and livestock industries on the management of emergency animal disease responses. Provisions include participatory decision making, risk management, cost sharing, the use of appropriately trained personnel and existing standards such as AUSVETPLAN. <i>See also</i> Compensation, Cost-sharing arrangements
Endemic animal disease	A disease affecting animals (which may include humans) that is known to occur in Australia. <i>See also</i> Emergency animal disease, Exotic animal disease
Enterprise	<i>See</i> Risk enterprise
Enzyme-linked immunosorbent assay (ELISA)	A serological test designed to detect and measure the presence of antibody or antigen in a sample. The test uses an enzyme reaction with a substrate to produce a colour change when antigen–antibody binding occurs.
Epidemiological investigation	An investigation to identify and qualify the risk factors associated with the disease. <i>See also</i> Veterinary investigation
Epidemiology	The study of disease in populations and of factors that determine its occurrence.
Exotic animal disease	A disease affecting animals (which may include humans) that does not normally occur in Australia. <i>See also</i> Emergency animal disease, Endemic animal disease
Exotic fauna/feral animals	<i>See</i> Wild animals

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Fomites	Inanimate objects (eg boots, clothing, equipment, instruments, vehicles, crates, packaging) that can carry an infectious disease agent and may spread the disease through mechanical transmission.
General permit	A legal document that describes the requirements for movement of an animal (or group of animals), commodity or thing, for which permission may be granted without the need for direct interaction between the person moving the animal(s), commodity or thing and a government veterinarian or inspector. The permit may be completed via a webpage or in an approved place (such as a government office or commercial premises). A printed version of the permit must accompany the movement. The permit may impose preconditions and/or restrictions on movements. <i>See also</i> Special permit
In-contact animals	Animals that have had close contact with infected animals, such as noninfected animals in the same group as infected animals.
Incubation period	The period that elapses between the introduction of a pathogen into an animal and the first clinical signs of the disease.
Index case	The first case of the disease to be diagnosed in a disease outbreak. <i>See also</i> Index property
Index property	The property on which the index case is found. <i>See also</i> Index case
Infected premises (IP)	A defined area (which may be all or part of a property) on which animals meeting the case definition are or were present, or the causative agent of the emergency animal disease is present, or there is a reasonable suspicion that either is present, and that the relevant chief veterinary officer or their delegate has declared to be an infected premises.
Local control centre	An emergency operations centre responsible for the command and control of field operations in a defined area.
Monitoring	Routine collection of data for assessing the health status of a population or the level of contamination of a site for remediation purposes. <i>See also</i> Surveillance

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Movement control	Restrictions placed on the movement of animals, people and other things to prevent the spread of disease.
National Biosecurity Committee	A committee that was formally established under the Intergovernmental Agreement on Biosecurity (IGAB). The IGAB was signed on 13 January 2012, and signatories include all states and territories except Tasmania. The committee provides advice to the Agriculture Senior Officials Committee and the Agriculture Ministers' Forum on national biosecurity issues, and on the IGAB.
National Management Group (NMG)	A group established to approve (or not approve) the invoking of cost sharing under the Emergency Animal Disease Response Agreement. NMG members are the Secretary of the Australian Government Department of Agriculture, Water and the Environment as chair, the chief executive officers of the state and territory government parties, and the president (or analogous officer) of each of the relevant industry parties.
Native wildlife	See Wild animals
OIE Terrestrial Code	OIE <i>Terrestrial Animal Health Code</i> . Describes standards for safe international trade in animals and animal products. Revised annually and published on the internet at: www.oie.int/international-standard-setting/terrestrial-code/access-online .
OIE Terrestrial Manual	OIE <i>Manual of diagnostic tests and vaccines for terrestrial animals</i> . Describes standards for laboratory diagnostic tests, and the production and control of biological products (principally vaccines). The current edition is published on the internet at: www.oie.int/en/standard-setting/terrestrial-manual/access-online .
Operational procedures	Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.
Outside area (OA)	The area of Australia outside the declared (control and restricted) areas.
Owner	Person responsible for a premises (includes an agent of the owner, such as a manager or other controlling officer).
Polymerase chain reaction (PCR)	A method of amplifying and analysing DNA sequences that can be used to detect the presence of viral DNA.

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Premises	A tract of land including its buildings, or a separate farm or facility that is maintained by a single set of services and personnel.
Premises of relevance (POR)	A premises in a control area that contains a live susceptible animal(s) but is not considered at the time of classification to be an infected premises, suspect premises, trace premises, dangerous contact premises or dangerous contact processing facility.
Prevalence	The proportion (or percentage) of animals in a particular population affected by a particular disease (or infection or positive antibody titre) at a given point in time.
Proof of freedom	Reaching a point following an outbreak and post-outbreak surveillance when freedom from the disease can be claimed with a reasonable level of statistical confidence.
Qualifiers	
- assessed negative	Assessed negative (AN) is a qualifier that may be applied to ARPs, PORs, SPs, TPs, DCPs or DCPFs. The qualifier may be applied following surveillance, epidemiological investigation, and/or laboratory assessment/diagnostic testing and indicates that the premises is assessed as negative at the time of classification.
- sentinels on site	Sentinels on site (SN) is a qualifier that may be applied to IPs and DCPs to indicate that sentinel animals are present on the premises as part of response activities (ie before it can be assessed as an RP).
- vaccinated	The vaccinated (VN) qualifier can be applied in a number of different ways. At its most basic level, it can be used to identify premises that contain susceptible animals that have been vaccinated against the EAD in question. However, depending on the legislation, objectives and processes within a jurisdiction, the VN qualifier may be used to track a range of criteria and parameters.
Quarantine	Legally enforceable requirement that prevents or minimises spread of pests and disease agents by controlling the movement of animals, persons or things.
Resolved premises (RP)	An infected premises, dangerous contact premises or dangerous contact processing facility that has completed the required control measures, and is subject to the procedures and restrictions appropriate to the area in which it is located.

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Restricted area (RA)	A relatively small legally declared area around infected premises and dangerous contact premises that is subject to disease controls, including intense surveillance and movement controls.
Risk enterprise	A defined livestock or related enterprise that is potentially a major source of infection for many other premises. Includes intensive piggeries, feedlots, abattoirs, knackeries, saleyards, calf scales, milk factories, tanneries, skin sheds, game meat establishments, cold stores, artificial insemination centres, veterinary laboratories and hospitals, road and rail freight depots, showgrounds, field days, weighbridges and garbage depots.
Sensitivity	The proportion of truly positive units that are correctly identified as positive by a test. <i>See also</i> Specificity
Sentinel animal	Animal of known health status that is monitored to detect the presence of a specific disease agent.
Seroconversion	The appearance in the blood serum of antibodies (as determined by a serology test) following vaccination or natural exposure to a disease agent.
Serosurveillance	Surveillance of an animal population by testing serum samples for the presence of antibodies to disease agents.
Serotype	A subgroup of microorganisms identified by the antigens carried (as determined by a serology test).
Serum neutralisation test	A serological test to detect and measure the presence of antibody in a sample. Antibody in serum is serially diluted to detect the highest dilution that neutralises a standard amount of antigen. The neutralising antibody titre is given as the reciprocal of this dilution.
Slaughter	The humane killing of an animal for meat for human consumption.

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Special permit	<p>A legal document that describes the requirements for movement of an animal (or group of animals), commodity or thing, for which the person moving the animal(s), commodity or thing must obtain prior written permission from the relevant government veterinarian or inspector. A printed version of the permit must accompany the movement. The permit may impose preconditions and/or restrictions on movements.</p> <p><i>See also</i> General permit</p>
Specificity	<p>The proportion of truly negative units that are correctly identified as negative by a test.</p> <p><i>See also</i> Sensitivity</p>
Stamping out	<p>The strategy of eliminating infection from premises through the destruction of animals in accordance with the particular AUSVETPLAN manual, and in a manner that permits appropriate disposal of carcasses and decontamination of the site.</p>
State coordination centre	<p>The emergency operations centre that directs the disease control operations to be undertaken in a state or territory.</p>
Surveillance	<p>A systematic program of investigation designed to establish the presence, extent or absence of a disease, or of infection or contamination with the causative organism. It includes the examination of animals for clinical signs, antibodies or the causative organism.</p>
Susceptible animals	<p>Animals that can be infected with a particular disease.</p>
Suspect animal	<p>An animal that may have been exposed to an emergency disease such that its quarantine and intensive surveillance, but not pre-emptive slaughter, is warranted.</p> <p>or</p> <p>An animal not known to have been exposed to a disease agent but showing clinical signs requiring differential diagnosis.</p>
Suspect premises (SP)	<p>Temporary classification of a premises that contains a susceptible animal(s) not known to have been exposed to the disease agent but showing clinical signs similar to the case definition, and that therefore requires investigation(s).</p>

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Swill Also known as ‘prohibited pig feed’, means material of mammalian origin, or any substance that has come in contact with this material, but does not include:

- i. milk, milk products or milk byproducts either of Australian provenance or legally imported for stockfeed use into Australia
- ii. material containing flesh, bones, blood, offal or mammal carcasses that is treated by an approved process¹
- iii. a carcass or part of a domestic pig, born and raised on the property on which the pig or pigs that are administered the part are held, that is administered for therapeutic purposes in accordance with the written instructions of a veterinary practitioner.
- iv. material used under an individual and defined-period permit issued by a jurisdiction for the purposes of research or baiting.

¹ In terms of (ii), approved processes are:

1. rendering in accordance with the Australian Standard for the Hygienic Rendering of Animal Products
2. under jurisdictional permit, cooking processes subject to compliance verification that ensure that a core temperature of at least 100 °C for a minimum of 30 minutes, or equivalent, has been reached
3. treatment of cooking oil, which has been used for cooking in Australia, in accordance with the National Standard for Recycling of Used Cooking Fats and Oils Intended for Animal Feeds
4. under jurisdictional permit, any other nationally agreed process approved by AHC for which an acceptable risk assessment has been undertaken and that is subject to compliance verification.

The national definition is a minimum standard. Some jurisdictions have additional conditions for swill feeding that pig producers in those jurisdictions must comply with, over and above the requirements of the national definition.

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Swill feeding	<p>Also known as 'feeding prohibited pig feed', it includes:</p> <ul style="list-style-type: none"> • feeding, or allowing or directing another person to feed, prohibited pig feed to a pig • allowing a pig to have access to prohibited pig feed • the collection and storage or possession of prohibited pig feed on a premises where one or more pigs are kept • supplying to another person prohibited pig feed that the supplier knows is for feeding to any pig. <p>This definition was endorsed by the Agriculture Ministers' Council through AGMIN OOS 04/2014.</p>
Trace premises (TP)	<p>Temporary classification of a premises that contains susceptible animal(s) that tracing indicates may have been exposed to the disease agent, or contains contaminated animal products, wastes or things, and that requires investigation(s).</p>
Tracing	<p>The process of locating animals, people or other items that may be implicated in the spread of disease, so that appropriate action can be taken.</p>
Unknown status premises (UP)	<p>A premises within a declared area where the current presence of susceptible animals and/or risk products, wastes or things is unknown.</p>
Vaccination	<p>Inoculation of individuals with a vaccine to provide active immunity.</p>
Vaccine	<p>A substance used to stimulate immunity against one or several disease-causing agents to provide protection or to reduce the effects of the disease. A vaccine is prepared from the causative agent of a disease, its products or a synthetic substitute, which is treated to act as an antigen without inducing the disease.</p>
- adjuvanted	<p>A vaccine in which one or several disease-causing agents are combined with an adjuvant (a substance that increases the immune response).</p>
- attenuated	<p>A vaccine prepared from infective or 'live' microbes that are less pathogenic but retain their ability to induce protective immunity.</p>
- gene deleted	<p>An attenuated or inactivated vaccine in which genes for non-essential surface glycoproteins have been removed by genetic engineering. This provides a useful immunological marker for the vaccine virus compared with the wild virus.</p>

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- inactivated	A vaccine prepared from a virus that has been inactivated ('killed') by chemical or physical treatment.
- recombinant	A vaccine produced from virus that has been genetically engineered to contain only selected genes, including those causing the immunogenic effect.
Vector	A living organism (frequently an arthropod) that transmits an infectious agent from one host to another. A <i>biological</i> vector is one in which the infectious agent must develop or multiply before becoming infective to a recipient host. A <i>mechanical</i> vector is one that transmits an infectious agent from one host to another but is not essential to the lifecycle of the agent.
Veterinary investigation	An investigation of the diagnosis, pathology and epidemiology of the disease. See also Epidemiological investigation
Viraemia	The presence of viruses in the blood.
Wild animals	
- native wildlife	Animals that are indigenous to Australia and may be susceptible to emergency animal diseases (eg bats, dingoes, marsupials).
- feral animals	Animals of domestic species that are not confined or under control (eg cats, horses, pigs).
- exotic fauna	Nondomestic animal species that are not indigenous to Australia (eg foxes).
Wool	Sheep wool.
Zero susceptible species premises (ZP)	A premises that does not contain any susceptible animals or risk products, wastes or things.
Zoning	The process of defining, implementing and maintaining a disease-free or infected area in accordance with OIE guidelines, based on geopolitical and/or physical boundaries and surveillance, to facilitate disease control and/or trade.
Zoonosis	A disease of animals that can be transmitted to humans.

Abbreviations

Disease-specific abbreviations

ABLV	Australian bat lyssavirus
CNS	central nervous system
IU	international unit
PPE	personal protective equipment
RABV	rabies lyssavirus
WHS	work health and safety
YBST	yellow-bellied sheath-tailed (bat)

Standard AUSVETPLAN abbreviations

ACDP	Australian Centre for Disease Preparedness
AN	assessed negative
ARP	at-risk premises
AUSVETPLAN	Australian Veterinary Emergency Plan
CA	control area
CCEAD	Consultative Committee on Emergency Animal Diseases
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVO	chief veterinary officer
DCP	dangerous contact premises

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DCPF	dangerous contact processing facility
EAD	emergency animal disease
EADRA	Emergency Animal Disease Response Agreement
EADRP	Emergency Animal Disease Response Plan
EDTA	ethylenediaminetetraacetic acid (anticoagulant for whole blood)
ELISA	enzyme-linked immunosorbent assay
GP	general permit
IETS	International Embryo Technology Society
IP	infected premises
LCC	local control centre
NMG	National Management Group
OA	outside area
OIE	World Organisation for Animal Health
PCR	polymerase chain reaction
POR	premises of relevance
RA	restricted area
RP	resolved premises
SCC	state coordination centre
SP	suspect premises
SpP	special permit
TP	trace premises
UP	unknown status premises
ZP	zero susceptible species premises

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