AUSVETPLAN

Disease Strategy

Australian bat lyssavirus

Version 3.0, 2009

AUSVETPLAN is a series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.

Primary Industries Ministerial Council

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.

Preface

This disease strategy for the management of Australian bat lyssavirus (ABLV) is an integral part of the **Australian Veterinary Emergency Plan**, or **AUSVETPLAN (Edition 3)**. AUSVETPLAN structures and functions are described in the AUSVETPLAN **Summary Document**. The strategy provides information about the disease (Section 1), the relevant risk factors and their treatment and the options for the management of a disease outbreak depending on the circumstances (Section 2) and the policy that will be adopted in the case of an outbreak (Sections 3 and 4).

This strategy has been produced in accordance with the procedures described in the **Summary Document** and in consultation with Australian national, state and territory governments, public health officials, and wildlife experts. This ABLV manual applies only to ABLV; there is a separate rabies **Disease Strategy**. The ABLV manual refers to public health guidelines developed by health authorities; further information concerning public health must be obtained from those authorities (see References and Further reading).

In Australia, ABLV is included as a Category 1 emergency animal disease in the *Government and Livestock Industry Cost Sharing Deed In Respect of Emergency Animal Disease Responses* (EAD Response Agreement).[1]

Text placed in square brackets [xxx] indicates that that aspect of the manual remains contentious 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.

Detailed instructions for the field implementation of AUSVETPLAN are contained in the disease strategies, operational procedures manuals, management manuals and wild animal manual. Industry-specific information is given in the relevant enterprise manuals. The full list of AUSVETPLAN manuals that may need to be accessed in an emergency is shown below.

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[1] Information about the EAD Response Agreement can be found at
www.animalhealthaustralia.com.au/programs/eadp/eadra.cfm

AUSVETPLAN manuals[2]

Disease strategies

Individual strategies for each of 35 diseases

Bee diseases and pests

Response policy briefs (for diseases not covered by individual manuals)

Operational procedures manuals

Decontamination

Destruction of animals

Disposal

Public relations

Valuation and compensation

Livestock management and welfare

Wild animal manual

Wild animal response strategy

Summary document

Enterprise manuals

Artificial breeding centres

Dairy processing

Feedlots

Meat processing

Poultry industry

Saleyards and transport

Zoos

Management manuals

Control centres management (Parts 1 and 2)

Animal Emergency Management Information System

Laboratory preparedness

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2 The complete series of AUSVETPLAN documents is available on the internet at
www.animalhealthaustralia.com.au/programs/eadp/ausvetplan/ausvetplan_home.cfm

Contents

Tables

1 Nature of the disease

Australian bat lyssavirus (ABLV) causes meningoencephalomyelitis, which is invariably fatal and is indistinguishable from rabies in humans and other animals. ABLV has caused the deaths of two people in Australia (for a review of potential human exposure, see McCall et al 2000).

ABLV was first reported in 1996 in bats in eastern Australia, and has been reported every year since then. Evidence of infection with ABLV has been reported in fruit bats (Megachiroptera, or flying foxes) and insectivorous bats (Microchiroptera).

1.1   Aetiology and pathogenicity

The rabies virus was believed to be unique and antigenically distinct from other members of the Rhabdoviridae family. In 1956, rabies-related viruses were first isolated in Africa and this warranted the creation of the *Lyssavirus* genus, which was initially divided into five serotypes. Isolations of new bat lyssaviruses in Europe and then Australia subsequently led to the genus being divided into seven genotypes (see Appendix 2). Within each genotype, sublineages correspond to variants circulating in specific regions and/or animal hosts.

Lyssaviruses show a strong evolutionary association with bats. Genotypes 2, 4, 5, 6 and 7 solely or predominantly infect bats. Based on molecular analyses, it is now argued that terrestrial biotypes of genotype 1 (classical rabies) evolved from bat lyssaviruses (Badrane and Tordo 2001).

The International Committee on Taxonomy of Viruses has formally classified ABLV as a separate species within the genus *Lyssavirus* of the family Rhabdoviridae (van Regenmortel et al 2000). ABLV is genetically separate from other lyssaviruses and has been assigned to genotype 7, although it is antigenically close to classical rabies virus. Isolates from flying foxes and from the insectivorous bat *Saccolaimus flaviventris* (yellow-bellied sheath-tailed bat) belong to genetically distinct lineages (see Figure 1.1). Genetic variation within each lineage is narrow (Guyatt et al 2003, Barrett 2004).
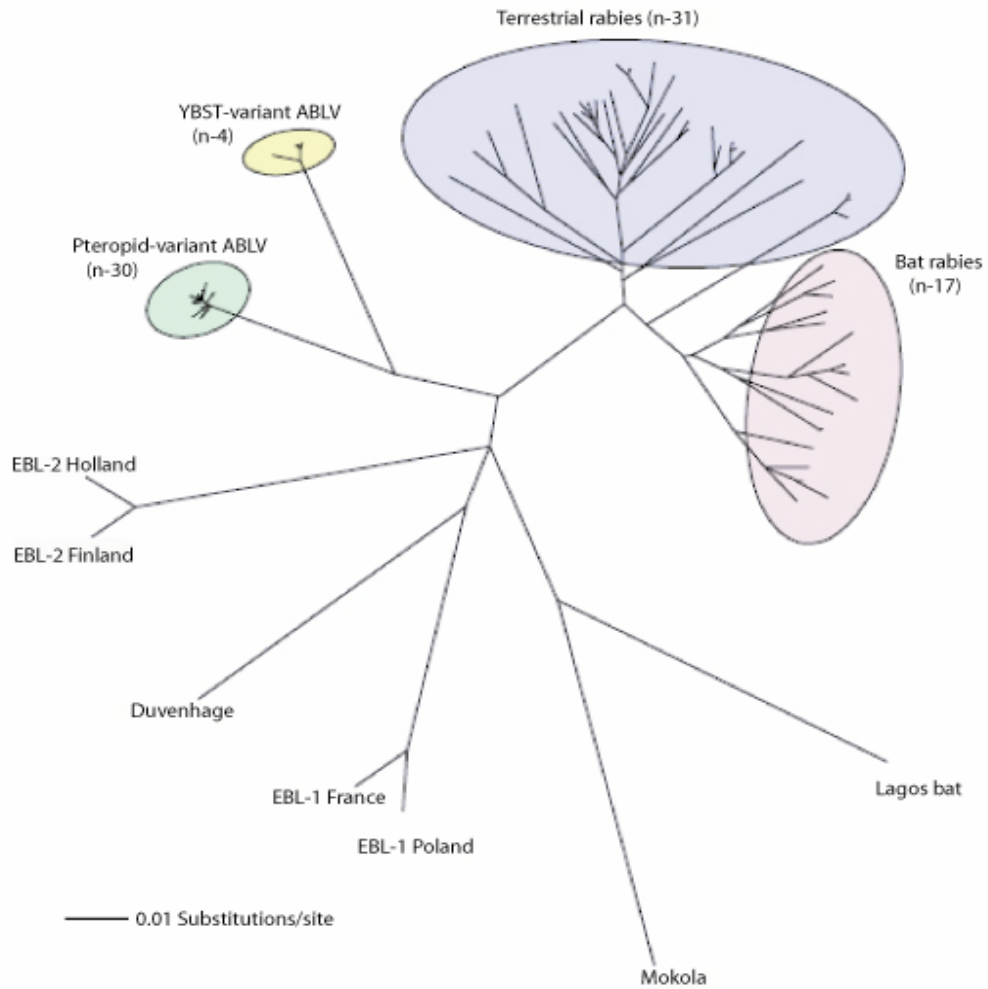
Unrooted neighbour joining phylogram generated from the complete N protein coding sequences of 30 pteropid-variant ABLV isolates, 4 yellow-bellied sheath-tailed bat-variant ABLV (YBST-variant ABLV) isolates, and 55 other rabies-like and rabies virus isolates. Branch lengths are proportional to evolutionary distances, as indicated by the distance bar. For details of virus isolates and GenBank accession details, and relationships within each shaded group, see Barrett (2004).
Source: Barrett (2004) (with permission)

Figure 1.1   Lyssavirus phylogeny

1.2   Susceptible species

1.2.1   Bats

All Australian bat species are considered susceptible to ABLV.

ABLV infection has been detected in four common species of pteropid fruit bats (Megachiroptera) that occur in mainland Australia:

- the black flying fox, *Pteropus alecto*;
- the little red flying fox, *P. scapulatus*;
- the grey-headed flying fox, *P. poliocephalus*; and
- the spectacled flying fox, *P. conspicillatus*.

Appendix 1 gives a brief guide to identifying the common Megachiroptera species.

Infection has been confirmed by virus isolation in one species of Microchiroptera, the yellow-bellied sheath-tailed bat (*Saccolaimus flaviventris*). Serological evidence of exposure to ABLV has been reported in seven genera, representing five of the six families of Australian Microchiroptera (Field 2005):

- *Chaerophon* and *Tadarida* (Molossidae);

- *Chalinolobus* and *Vespadelus* (Vespertilionidae);

- *Hipposideros* (Hipposideridae);

- *Macroderma* (Megadermatidae); and

- *Saccolaimus* (Emballonuridae).

1.2.2   Domestic animals

ABLV has not been recognised in domestic animals. However, other lyssaviruses naturally infect and cause rabies-like disease in a broad spectrum of domestic mammal species. For example, bat biotypes of rabies virus infect a range of mammals, including cats, cattle and horses, and natural infection with European bat lyssavirus type 1 has been demonstrated in cats and sheep suffering from neurological disorders (Tjørnehøj et al 2006, Dacheux et al 2009). This suggests that occasional transmission of ABLV to other mammalian species is likely.

Transmission of ABLV to individual animals of other species is unlikely to result in the establishment of persistent cycles in these species, as this would require adaptation of the virus strain to the new host species. At present, surveillance data on domestic animals are limited, and only limited experimental studies on a few species of animals have been conducted. Consequently, little is known about the host range and pathogenicity of ABLV in mammals other than bats and humans.

A preliminary study at the CSIRO Australian Animal Health Laboratory (AAHL) on cats and dogs inoculated with ABLV was inconclusive (McColl et al 2007). In this study, all the animals (three cats and five dogs) seroconverted after intramuscular inoculation with ABLV. There was no evidence of ABLV excretion in saliva, no detection of virus or antigen at necropsy, and only mild transient behavioural changes. All animals survived the duration of the study. The finding of antibody in the cerebrospinal fluid suggests that ABLV replicated in the central nervous system of the animals. However, it is not clear whether the outcomes of this trial are relevant to natural infection, as a cell culture–derived multiple passage isolate was used as the inoculum. The natural end-point of ABLV infection in dogs and cats is unknown. Further studies in Australian domestic and wild carnivore species are necessary to more conclusively demonstrate the ability of ABLV to infect dogs and cats (McCall et al 2005).

1.2.3   Other Australian animals

ABLV has not been recorded in any wild animal species except bats, but no surveys have been conducted to determine its prevalence.

No cases of ABLV infection in Australian mammals other than bats have been reported, although a small number of animal exposures to ABLV-positive bats have been investigated ($n < 10$).

Fatal neurological disease, similar to that caused by other lyssaviruses, has been reproduced experimentally in mice inoculated with ABLV by peripheral and intracerebral routes (Barrett 2004).

A number of recent papers have reported spillovers of bat-variant genotype 1 rabies virus and European bat lyssaviruses to terrestrial species (Badrane and Tordo 2001; Daoust et al 1996; Krebs et al 2002, 2003; Fooks et al 2003; Muller et al 2004; Vos et al 2004). An outbreak of bat-variant rabies in skunks subsequent to spillover has also been reported (Krebs et al 2002, Niezgoda et al 2003).

1.2.4   Humans

Despite apparently hundreds of potential human exposures to ABLV, only two cases of infection have been described to date. Humans can be infected when bitten or scratched by an infected bat. The two human deaths were both from a disease indistinguishable from rabies (see Section 1.3.2).

1.3   World distribution and occurrence in Australia

1.3.1   World distribution

Although ABLV has not been isolated outside Australia, it is likely that Asia has antigenically similar viruses because antibodies to ABLV have been detected in bats in the Philippines (Arguin et al 2002).

'Rabies' has been reported in Megachiroptera in Thailand (Smith et al 1967) and India (Pal et al 1980), but no isolates of the causative viruses were retained for antigenic or molecular characterisation. It is unclear whether these cases were caused by genotype 1 rabies virus or by another lyssavirus, possibly ABLV.

Detection of other bat lyssaviruses is common in the Americas and Western Europe, but rare in Africa and Eurasia. However, these viruses have been detected in microchiropteran bats wherever sufficiently sensitive surveillance systems have been used. Hence, it is likely that lyssaviruses occur in microchiropteran populations in most areas of the world.

1.3.2   Occurrence in Australia

General

The natural history of ABLV is poorly understood.

ABLV-infected bats have been reported from the northern and eastern coastal areas of Australia. Inland, ABLV has been found in bats at Narromine in New South Wales, and near Mount Isa in Queensland (Garner and Bunn 1997, Field and Ross 1999). Serological evidence suggests a wide geographical distribution in bats in Australia (Field 2005).

At the time of publication, 6 of 13 megachiropteran species and at least 22 of 63 microchiropteran species in Australia have been tested for ABLV (see Appendix 3). Table 1.1 presents the number of megachiropteran and microchiropteran bats that tested positive for ABLV by at least one of the following tests — fluorescent

antibody test (FAT), immunoperoxidase staining, polymerase chain reaction, or virus isolation — following opportunistic sampling by the Australian states and territories from 1996 to 2005. Initial targeted surveillance, following the first diagnosis of ABLV in 1996, was gradually replaced by opportunistic sampling from 1997.

Table 1.1   Australian bat lyssavirus surveillance of bats by state (1996–2005)

State	Number of bats tested				Number of bats testing lyssavirus positive[a]			
	Mega-bats	Micro-bats	NS	Total	Mega-bats	Micro-bats	NS	Total
Qld	1240	280	88	1608	56	5	7	68
NSW	227	59	4	290	22	0	1	23
Vic	46	30	4	80	6	0	0	6
Tas	1	15	0	16	0	0	0	0
SA	6	4	10	20	0	0	0	0
WA	5	3	2	10	5	0	0	5
ACT	0	0	1	1	0	0	0	0
NT	1	0	0	1	1	0	0	1
Total	1526	391	109	2026	90	5	8	103

NS = not specified
a Includes specimens testing positive by at least one of fluorescent antibody test, immunoperoxidase staining, polymerase chain reaction, or virus isolation
Source: CSIRO-AAHL, Queensland Department of Health 'Bat Stats' database (G Smith, pers comm, November 2006, National Animal Health Information System)

The number of animals sampled rose rapidly from late 1996 to 1997 and then fell steadily until January 2002 as public interest in providing samples declined. Since 2005, the number of submissions has been relatively low and the total number of lyssavirus-positive bats detected in Australia has remained reasonably steady, usually between three and eight per year. A higher number of positive results ($n = 31$) was associated with the peak year of testing in 1997 (CSIRO-AAHL; Queensland Department of Health 'Bat Stats' database (G Smith, pers comm, November 2006, National Animal Health Information System)). Most positive results seem to come from Queensland, followed by New South Wales, which probably reflects the sampling effort rather than the distribution of ABLV.

ABLV has not been found in more than 300 clinically normal, wild-caught Australian bats, suggesting that its prevalence in this group of animals is extremely low.

Passive surveillance through submission and laboratory examination of sick bats can extend knowledge of the disease, and is helpful as a sentinel procedure. Passive surveillance positively biases the sample to the 'sick' subpopulation of bats and therefore enhances the detection rate.

Megachiroptera

Prevalence of viral antigen in opportunistic submissions of sick, injured and/or orphaned Megachiroptera, as detected by FAT, is typically 5–10%, but may be as low as 1% or as high as 17% depending on the species (7.8% in black flying fox, 16.9% in little red flying fox, 4.6% in grey-headed flying fox, and 1.0% in spectacled flying fox). Adult bats and bats with central nervous system (CNS) clinical signs

have a higher prevalence than bats of the same species that are juveniles or have non-CNS clinical signs, respectively. In one study, sick and injured adult little red flying foxes presenting with CNS signs had a prevalence of approximately 60% (Barrett 2004). Seroprevalance in sick, injured and orphaned Megachiroptera is up to 20% (Field 2005).

From 1996 to 2001, none of 475 wild-caught Megachiroptera from northern Australia showed serological evidence of ABLV infection. Statistically, this is consistent with a prevalence of infection in the wild-caught study population of less than 1% (at a 95% confidence level, assuming 100% test sensitivity) (Field 2005). The 95% binomial confidence puts the estimate between 0 and 0.7%.

Microchiroptera

Viral antigen was not detected in any clinically normal wild-caught microchiropteran bats collected around Australia; this was based on screening with FAT on 668 brain-only samples, and FAT and rapid fluorescent focus inhibition test (RFFIT) for neutralising antibodies on 318 brain and blood samples. Statistically, this gives a point prevalence estimate of 0% in the wild-caught study population (at a 95% confidence level and assuming 100% test sensitivity). The 95% binomial confidence interval is 0 to 0.37%. This is consistent with findings from the United States, Mexico and the Philippines for other lyssavirus biotypes in bats (Steece and Altenbach 1989, Arguin et al 2002).

Seroprevalence in sick, injured and rescued Microchiroptera (up to 5%) is lower than for Megachiroptera (up to 20%), but also appears to vary with species. One study found that the yellow-bellied sheath-tailed bat had significantly higher antibody prevalence (up to 62.5%) than other species, suggesting that this bat plays an important role in the ecology of ABLV (Field 2005).

Implications of vaccination for Australia's rabies-free status

The OIE *Terrestrial Animal Health Code* currently accepts that the European bat lyssavirus genotypes (EBL1 and EBL2) and ABLV are different from rabies virus. The presence of ABLV and the use of rabies vaccines do not affect Australia's rabies-free status.

1.4   Diagnostic criteria

1.4.1   Clinical signs

Bats

Bats affected with ABLV show a range of clinical signs, including overt aggression, paresis and paralysis, seizures and tremors, weakness, respiratory difficulties, and change of voice (see Table 1.2 and Appendix 4). These signs, although commonly associated with ABLV, are not exclusive to ABLV infection. Affected animals are often found on the ground or low in a tree and are unwilling or unable to fly. ABLV must also be considered in dead or moribund bats, or those that appear to be suffering from another disease (for example, lead poisoning or angiostrongylosis).

Table 1.2   Clinical recognition of bats likely to be ABLV-positive

Clinical signs and other characteristics	Ease of recognition of ABLV infection	Comments
Dead or moribund	Difficult	Indistinguishable from other moribund bats.
Poor or nonspecific clinical description	Difficult	The number of bats in this category can be minimised if veterinarians make detailed and specific inquiries about the bats' physical and neurological abilities.
Weakness, with respiratory difficulties	Difficult	The presence or development of respiratory abnormalities in a bat with lyssavirus-like weakness should not reduce the otherwise high index of suspicion for ABLV.
Yellow-bellied sheath-tailed bats	High index of suspicion	Due to the extraordinarily high prevalence of ABLV in this species (62.5%), and the difficulty associated with safely examining this small animal, all sick, injured, or orphaned yellow-bellied sheath-tailed bats should be submitted for ABLV testing.
Overt aggression	High index of suspicion	Wild bats are usually not aggressive. Most bat bites and scratches are clearly defensive. Any suggestion by experienced wildlife carers that a bat is uncharacteristically aggressive or 'angry' should be considered very seriously. These bats are particularly likely to attempt to bite or scratch people and pose a high risk of human infection.
Paresis, paralysis of hind limbs	High index of suspicion	Although there are other causes of paresis (see Section 1.4.4), few have a good prognosis, and all bats that have hind-limb paresis and/or are unable to hang should be submitted for ABLV testing.
Generalised paresis	High index of suspicion	Bats found with unexplained generalised weakness or with progressive weakness should be submitted for ABLV testing.
Abnormal function of mouth or larynx	High index of suspicion	These clinical signs are uncommon in ABLV-negative bats. All bats with a history that includes difficulty swallowing, abnormal salivation or tongue movements, odd yawning, etc, should be submitted for testing.
'Fitting', twitching and tremors	High index of suspicion	All bats showing evidence of CNS and/or cranial nerve involvement should be submitted for ABLV testing.
History or clinical signs suggesting a specific, non-ABLV diagnosis	Low index of suspicion	Perhaps the most difficult ABLV-positive bat to recognise. Many of the >90% of rescued bats that are ABLV negative have histories and clinical signs, such as being caught in barbed-wire fences, electrical burns, being found as orphans, etc, that suggest a specific, non-ABLV reason for rescue. ABLV-positive bats 'masquerading' as one of the common ABLV-negative bats are unlikely to be recognised.

ABLV = Australian bat lyssavirus; CNS = central nervous system
Source: modified from Barrett (2004) (with permission)

Humans

Based on the only two recognised human cases, ABLV disease in humans has the same clinical picture as rabies. Clinical signs in the cases included vomiting, headache, fevers, dysphagia, facial palsy and difficulty in speaking, agitation, muscular spasms and progressive weakness and ataxia.

The incubation periods in the two patients were a few weeks (no clear history) and 27 months, with a clinical course of 20 days and 19 days respectively. Both had

severe nonsuppurative meningoencephalitis (Samaratunga et al 1998, Hanna et al 2000).

1.4.2 Pathology

Gross lesions in bats

No consistent macroscopic lesions have been seen in infected bats (McColl et al 2002, Barrett 2004).

Microscopic lesions in bats

There is usually a nonsuppurative meningoencephalomyelitis, with perivascular lymphocytic cuffs, gliosis, meningitis, neuronal degeneration, intracytoplasmic vacuolation and neuronal intracytoplasmic eosinophilic inclusions (Negri bodies) (Hooper et al 1997, McColl et al 2002, Barrett 2004).

The severity and extent of lesions are extremely variable, and lesions may be absent. Histological examination is not a reliable method of detecting ABLV or other lyssaviruses.

Lesions in other animals

Experimentally, two of five dogs and one of three cats had ABLV antibodies in the cerebrospinal fluid 3 months after intramuscular inoculation with ABLV. The dogs had mild, transient behavioural changes 2–3 weeks after inoculation, but all recovered. There was no evidence of virus in the saliva, nor was there evidence of virus or viral antigen in any of the tissues taken at postmortem examination 3 months after inoculation. There were no gross or histological lesions in the CNS of any of the animals.

1.4.3 Laboratory tests

A positive result in any species must be notified immediately to the chief veterinary officer of the state or territory concerned, who will immediately notify their public health equivalent.

Methods for diagnosing ABLV infection in humans, bats or other animals are similar to those used for classical rabies. Specific laboratory diagnostic tests are necessary to confirm lyssavirus or ABLV infection (Barrett 2004) as neither clinical signs, nor gross or histological pathology are pathognomonic. The tests currently available for ABLV diagnosis are listed in Table 1.3.

FAT is the initial test of choice for the diagnosis of lyssavirus infections in domestic or wild animals because it is the most rapid and reliable test. It involves the application to a smear of brain tissue of specific fluorescein-labelled antibodies directed against the viral nucleocapsid proteins. Current FAT reagents react to all lyssaviruses and are not ABLV specific. Differentiation of ABLV from other lyssaviruses requires characterisation of the viral genome by molecular genetic techniques, such as polymerase chain reaction (PCR) and sequencing.

Serology is a valuable tool for ABLV surveillance in flying foxes and microchiropteran bats because it provides an efficient and generally nondestructive mechanism for detecting previous infection at a population level.

However, small blood volumes and limited serum harvests from many microchiropteran species present challenges. In Australia, it is likely that the sensitivity and specificity of ABLV antibody detection would be maximised by testing against ABLV antigen, rather than the cross-reacting rabies antigen (Field 2005).

Table 1.3   Tests currently available for ABLV

Test	Specimen	Test detects	Time taken to obtain result
FAT	Fresh brain	Lyssavirus antigen	0.5 days[a]
TaqMan assay (separate assays for pteropid and insectivorous ABLV)	Fresh brain	Viral genome	1 day[a]
PCR for generic lyssavirus (nested RT-PCR and sequencing)	Fresh brain	Viral genome	2–3 days
Competitive ELISA	Serum and plasma	Rabies neutralising antibody	2 days
Virus isolation using neuroblastoma cell cultures	Fresh brain	Live virus	5 days
Immunohistochemistry	Formalin-fixed brain	Lyssavirus antigen	2 days
Serum neutralisation test (rabies RFFIT)	Serum	Rabies neutralising antibody	3 days
Serum neutralisation test (ABLV FAVN)	Serum	ABLV neutralising antibody	5 days

ELISA = enzyme-linked immunosorbent assay; FAT = fluorescent antibody test; FAVN = fluorescent antibody virus neutralisation test; RFFIT = rapid fluorescent focus inhibition test; RT-PCR = real-time polymerase chain reaction
a Same day
Note: Several of the tests are also offered by state animal and public health laboratories in Australia (check with local laboratories)
Source: Information provided by AAHL, 2006 (refer to AAHL for most up-to-date information)

Specimens required

All bats should be submitted whole to the laboratory.

For all species, whole animals, severed heads or unpreserved brains should be chilled and forwarded on ice to the testing laboratory. Freezing should be avoided unless chilling is not possible. If the sample does not include the brain, either the remainder of the whole animal, the remains of the head, the trigeminal ganglion or the spinal cord should be submitted.

Unless the operator is vaccinated and experienced, the head or brain should not be removed before submission because of the risk of self inoculation. In the much smaller microchiropteran bats, considerable architectural damage may occur to brains during removal.

NOTE: Animals should not be shot through the head.

Care must be taken to identify the bat species. This requires experience, particularly for some microchiropteran bats. As much information as possible should be collected to assist identification (see Appendix 1). If accurate

identification is not possible, the whole carcase should be submitted to, and retained by, the laboratory so that it can be properly identified. Photographs can also aid identification.

At the laboratory, both unpreserved and formalin-fixed samples of other tissues could be collected if a differential diagnosis is required. Serum may be required for other purposes, such as the serum neutralisation test (see Table 1.3).

Sample submission and transport

Specimens should initially be sent to the state or territory veterinary laboratory (and/or other appropriate laboratory), from where they may be forwarded to AAHL for testing or confirmation of positive or suspicious test results.[3] If a potential human exposure has occurred, the state or territory laboratory will immediately notify the relevant public health department.

For exclusion of rabies virus infection in domestic animals, specimens must be submitted to AAHL (see the **Disease Strategy** for rabies).

Before shipping specimens, submitters should contact the receiving laboratory to discuss arrangements for sampling, transport and sample reception. Samples should be submitted in accordance with agreed jurisdictional protocols.

Appropriate laboratories for assessing samples include:

- AAHL;[4]

- Queensland Health Forensic and Scientific Services;[5] and

- Queensland Biosecurity Sciences Laboratory (Queensland Primary Industries and Fisheries).[6]

In states and territories other than Queensland, submission occurs through the government department of primary industries laboratory. In Queensland, a two-tiered system is used. If a bat has not bitten or scratched a person, it is sent to the Biosecurity Sciences Laboratory. If there is suspected human involvement, the bat is submitted to Queensland Health Forensic and Scientific Services. These laboratories will provide advice on sample submission and transport procedures.

Further information on testing is available on the website of the Australian Government Department of Health and Ageing.[7]

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[3] In Queensland, testing for ABLV is also available through Queensland Health Forensic and Scientific Services (www.health.qld.gov.au/qhcss/qhss/default.asp)

[4] CSIRO Australian Animal Health Laboratory, 5 Portarlington Road, Geelong VIC 3212 (contact the duty veterinarian)

[5] 39 Kessels Road, Coopers Plains QLD 4108

[6] Animal Research Institute, 665 Fairfield Road, Yeerongpilly QLD 4105 (contact the duty veterinarian). (This laboratory will be colocated with Forensic and Scientific Services at 39 Kessels Road, Coopers Plains, from April 2010.)

[7] www.health.gov.au/internet/main/publishing.nsf/Content/cda-pubs-other-bat_lyssa.htm

Case definition

Terms used to describe infection or possible exposure to ABLV in all species of animals, including the case definition, are listed in Table 1.4.

Confirmation of lyssavirus infection requires a positive result to a definitive laboratory-based, validated diagnostic test, such as FAT, PCR, immuno-histochemistry or virus isolation performed at an accredited laboratory. ABLV must be distinguished from other lyssaviruses (eg rabies) by sequence analysis or another suitable typing method.

ABLV cases are suspected when there are behavioural or clinical signs consistent with ABLV infection (see Table 1.2). These cases have a high index of suspicion. Cases where there are no behavioural or clinical signs consistent with ABLV (for example, in apparently healthy bats captured as part of biological or survey studies) have a low index of suspicion. Positive serology does not constitute a diagnosis, but is evidence of exposure.

Table 1.4   Case definition and terms used

Term	Plain English	Laboratory	Comment
Confirmed diagnosis of ABLV (ABLV positive)	Laboratory-confirmed diagnosis specific to ABLV.	ABLV confirmed by ABLV-specific nucleic acid or antigen typing tests.	Definitive diagnosis of ABLV and case definition.
Confirmed diagnosis of lyssavirus, presumptive diagnosis of ABLV (Presumptive ABLV positive)	Laboratory-confirmed diagnosis of lyssavirus infection that is almost invariably ABLV.	Lyssavirus confirmed by tests, but not confirmed as ABLV by ABLV-specific nucleic acid or antigen typing tests.	In the absence of evidence of any other lyssaviruses in Australia, evidence of lyssavirus infection provides a very high index of suspicion for ABLV specifically.
Possible ABLV	History and/or clinical signs consistent with ABLV (Table 1.2), but no laboratory testing done.	No testing done.	High index of suspicion and cannot rule out ABLV. Includes bats found dead.
ABLV negative	Negative laboratory tests for either lyssavirus generally or all variants of ABLV specifically.	One or more antigen or nucleic acid tests do not show evidence of lyssavirus or ABLV infection. If tests used are specific for variants of ABLV (ie pteropid or YBST-variants), a negative result for all variants is required.	The potential for a false negative result is reduced by using multiple tests, testing for both antigen and nucleic acid and using tests with potential to detect a range of lyssaviruses, including new variants (ie less specific tests).

ABLV = Australian bat lyssavirus, YBST = yellow-bellied sheath-tailed bat
Note: All laboratory testing must occur at an accredited laboratory.

1.4.4   Differential diagnosis

Bats

Barrett (2004) discussed causes of clinical neurological syndromes in flying foxes, and concluded that:

- ABLV is one of a number of conditions that can cause clinical neurological syndromes in flying foxes.

- Most (79%) neurological syndromes in flying foxes are caused either by ABLV (32%), spinal and head injuries (29%), or neuro-angiostrongylosis (infection of the brain with a nematode parasite of the *Angiostrongylus* genus) (18%) (Table 1.5).

- On initial presentation, bats with the paretic form of ABLV, neuro-angiostrongylosis or head trauma are clinically indistinguishable. Given the difficulty of distinguishing between these neurological syndromes, the risks associated with caring for bats infected with ABLV, and the poor prognosis of all three conditions, wildlife carers should be urged not to care for flying foxes with neurological disease, but to submit them for lyssavirus testing.

- ABLV is the most common cause of paresis, paralysis or overt aggression in flying foxes (32% of cases).

- A bat with a comparatively long (>7 days) and stable history of ABLV-like paresis is highly likely to have neuro-angiostrongylosis rather than ABLV.

Table 1.5 lists outcomes of investigations of CNS disorders in 100 flying foxes.

Table 1.5   Aetiology for 100 flying foxes with clinical signs suggesting CNS disease

Diagnosis	Percentage of cases[a]
ABLV	32
Spinal and head injuries	29
Neuro-angiostrongylosis (infection of the brain with a nematode parasite of the *Angiostrongylus* genus)	18
Congenital hydrocephalus	2
Bacterial meningoencephalitis	2
Vascular hepatopathy	1
Chronic injury with mydriasis	1
Lead poisoning	0
No diagnosis	16

a The total number of diagnoses is 101 because one flying fox had both neuro-angiostrongylosis and a spinal injury
Source: Barrett (2004) (with permission)

Humans

The main differential diagnosis for ABLV in humans is rabies; consideration of other possible differential diagnoses should be discussed with human health authorities.

Other animals

Classical rabies is the most important differential diagnosis for ABLV in animals; the two aetiologies can only be distinguished by genetic or antigenic typing in the laboratory (see the **Disease Strategy** for rabies).

As with rabies, other causes of neurological dysfunction should be considered as differential diagnoses in ABLV. Differential diagnoses include:

- viral encephalitides

  - rabies

  - canine distemper and infectious canine hepatitis

  - Aujeszky's disease

  - Borna disease

  - infection with eastern, western or Venezuelan equine encephalomyelitis viruses

  - infection with West Nile virus, Japanese encephalitis virus or other flaviviruses

  - infection with various insect-borne reoviruses;

- bacterial and mycotic diseases of the CNS, including listeriosis and cryptococcosis;

- poisons, including 1080 (sodium fluoroacetate), heavy metals (such as lead), chlorinated hydrocarbon and organophosphate pesticides, urea and nitrogen trichloride;

- protozoal infections, including babesiosis and toxoplasmosis;

- foreign bodies in the oropharynx or oesophagus and other traumatic injuries; and

- acute psychoses in dogs and cats.

1.4.5 Treatment of infected animals

There is no effective treatment for clinically affected animals.

Post-exposure vaccination with rabies vaccine during the preclinical period may prevent the development of clinical disease by promoting subclinical resolution of infection.

1.5 Resistance and immunity

1.5.1 Innate and passive immunity

Little is known about innate immunity of animals to ABLV and other lyssaviruses.

The role of passive maternal antibodies in providing immunity to ABLV and other lyssaviruses is presumed to be limited.

Passive immunity from post-exposure administration of rabies immunoglobulin is effective in reducing the case rate for rabies in humans and other animals.

1.5.2 Active immunity

In other countries, naturally occurring anti-rabies virus antibodies have been reported in clinically well bats, other animals, and humans. In New Mexico, Steece and Altenbach (1989) found that 69% of 750 adult female Mexican free-tailed bats (*Tadarida braziliensis mexicana*) had IgG antibody to rabies virus, and concluded that recovery from rabies virus infection was occurring in these bats.

1.5.3   Vaccination

General

There is no vaccine specifically against ABLV. Because ABLV is very closely related to rabies virus, it is believed that rabies vaccines provide a high degree of cross-protection against ABLV (Badrane et al 2001).

Animal rabies vaccines are available as parenteral vaccines (suitable for captive or domestic animals) and oral vaccines that are typically incorporated into baits for population vaccination of wild carnivores (eg foxes in Europe). Aerial baiting using oral vaccines has successfully eradicated sylvatic rabies from defined areas in Germany and other parts of Europe.

Permits for two parenteral vaccines have been issued by the Australian Quarantine and Inspection Service for use on animals for export under control of the Chief Quarantine Officer — Animals; some imported animals may also be vaccinated. These vaccines, which are available in Australia, are 'Trimune' (Fort Dodge Laboratories; imported by CSL Limited) and 'Nobivac® Rabies' (Intervet, Netherlands; imported by Intervet Australia Ltd).

Post-exposure vaccination

Although there is no definitive information, post-exposure vaccination may be effective in nonhuman animals. Animal rabies vaccines are presumed to reduce the risk of development of clinical disease by stimulating an immune response that leads to subclinical resolution of infection.

Comprehensive post-exposure rabies protocols require:

- passive immunity, through the administration of anti-rabies immunoglobulin (necessary for protection against clinical disease that might occur after a short incubation period)
- active immunity, through administration of a series of rabies vaccinations.

Anti-rabies immunoglobulin is expensive and of variable supply. It may be used for optimal post-exposure management of human exposures to rabies.

Post-exposure management using rabies vaccine alone is presumed to be effective where the timing of vaccination in relation to exposure allows for a sufficient response and subclinical resolution before the onset of clinical disease.

Rabies vaccination protocols require an immune response of 0.5 IU/mL to indicate protection against rabies virus. An anti-rabies titre of at least 2 IU/mL following vaccination has been estimated as sufficient to allow cross-protection against ABLV. This has not been validated using challenge studies.

A vaccination protocol that leads to seroconversion and a titre of at least 2 IU/mL by day 21–28, with no development of clinical signs for a further 3 weeks, may provide confidence that the animal no longer poses a risk of infection of ABLV to others.

However, it is possible that a vaccinated infected animal will develop clinical ABLV disease before developing an effective response to the vaccine.

The ability of antibodies elicited against the rabies human diploid cell vaccine (HDCV) to neutralise European bat lyssaviruses (types 1 and 2), ABLV and classical rabies virus has been evaluated using modified fluorescent antibody virus neutralisation assays. Of the human postvaccinal sera tested, 96% (48 of 50) cross-neutralised these viruses (antibody titre = 0.5 IU/mL). Cross-protection using inbred mice (RIII, k/k haplotype) was also assessed. Mice were given HDCV (twice by the intraperitoneal route) and challenged (intracranially or peripherally) with a lethal dose of the individual viruses. The vaccine conferred statistically significant protection in 80–100% of animals challenged via the peripheral route. Levels of protection were lower for intracranial challenge (Brookes et al 2005).

A small number of published articles suggest that vaccination and immunoglobulin can be effective in preventing clinical rabies in exposed unvaccinated animals. A study in Texas indicated that immediate post-exposure rabies vaccination with at least one booster vaccination and 90 days of strict isolation was an effective post-exposure prophylaxis protocol in unvaccinated animals (Clark and Wilson 1996). However, no therapy or protocol has been registered for use in post-exposure treatment of domestic animals in the United States.

No other recent overseas studies provide relevant information about the use of post-exposure vaccination to manage rabies.

Vaccination of bats

In an experiment using bats, 36 black and grey-headed flying foxes were vaccinated with one (day 0) or two (day 0 and day 28) doses of Nobivac® Rabies vaccine. All bats responded to the vaccine with a rabies RFFIT titre of more than 0.5 IU/mL, which is nominally indicative of protective immunity against rabies. Plasma from bats with rabies titres of more than 2 IU/mL had cross-neutralising ABLV titres of more than 1:154 (Barrett 2004). However, it was beyond the resources of the trial to demonstrate that rabies-vaccinated flying foxes were cross-protected against ABLV. More comprehensive in vivo studies are needed to determine the efficacy of rabies vaccines against ABLV variants. The titre corresponding to cross-protection against ABLV is not known.

Vaccination of wild bats against ABLV is not feasible due to a lack of an effective delivery method.

Vaccination of other animals

Overseas experience with wildlife vaccination against rabies suggests that oral vaccination using modified rabies virus baits could be a useful approach to the control of ABLV in wildlife. Information on the use of rabies vaccine can be found in the **Disease Strategy** for rabies.

The effect of vaccination of a domestic animal with rabies vaccine before or after exposure to ABLV is not known. If, as is assumed in humans, rabies vaccination confers cross-protection against both pteropid-variant and YBST-variant ABLV, then pre-exposure or post-exposure vaccination could decrease the risk of these animals developing clinical disease and potentially transmitting ABLV (Barrett 2004).

Vaccination of humans

Pre-exposure vaccination (with rabies vaccine) of people who handle bats and ABLV minimises the risk of human infection.

Groups most at risk in Australia include those who work with, treat or handle bats and people who work with ABLV. They include bat and wildlife carers, zoo keepers and zoo-based veterinarians, researchers, laboratory staff, and veterinarians and veterinary nurses who provide services to wildlife carer groups. These individuals are routinely vaccinated against rabies, and their level of protection is monitored.

The current indications for pre-exposure and post-exposure rabies vaccination, recommended dosage and regimen are described in the *Australian Immunisation Handbook* (ATAGI 2008). The handbook includes information about vaccination of people who work with live bat lyssavirus in research laboratories, other laboratory workers (such as those performing bat lyssavirus diagnostic tests), and veterinarians and their assistants who come into contact with bats.

Relevant health authorities should be contacted for current information about vaccination of people (see Appendix 6).

1.6   Epidemiology

In Australia, megachiropteran and microchiropteran bats are widespread. These species are protected.

There is no specific evidence that animals other than bats can transmit ABLV and no evidence that ABLV has been transmitted to a person from a host other than bats (McCall et al 2005). However, spillover to other mammals of other lyssaviruses carried by bats has been reported, although rarely. The lack of definitive science and targeted surveillance specific to ABLV means that transmission of ABLV from bats to other mammals cannot be ruled out (Bingham 2003).

The frequency of ABLV infection is significantly higher in sick, injured and rescued bats than in clinically normal bats. The risk to people in contact with these types of bats is therefore greater, particularly if the bats show CNS signs consistent with ABLV infection.

In rabies-endemic countries the detection of naturally occurring anti-rabies virus antibodies in clinically well bats and other animals, including humans, strongly suggests subclinical resolution of inapparent lyssavirus infection. There is some evidence for resolution of subclinical or mild clinical ABLV infection in dogs under experimental conditions. Although it is unclear what happens to these animals after ABLV infection (McColl et al 2007), there is general consensus that lyssavirus infections do not produce a persistent, infectious 'carrier' state in animals.

Megachiroptera

Mature flying foxes are more than twice as likely as immature flying foxes to be ABLV positive using FAT. Age is commonly a risk factor for horizontally transmitted infectious diseases that provoke a persistent antibody response (Mills

and Childs 1998), since older animals have had a longer opportunity for exposure and infection.

The lifestyle of bats may have a major influence on the persistence and transmission of lyssavirus. 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 yellow-bellied sheath-tailed bat (*Saccolaimus flaviventris*, Microchiroptera) tends to be solitary when roosting, although small groups of two to six bats are sometimes seen.

There appears to be a higher probability of exposure to ABLV in all megachiropteran species in the first six months of the year (Field 2005). Temporal variation in exposure may be associated with seasonal changes in reproductive behaviour and nomadic movement (ibid). The little red flying fox (*P. scapulatus*) is a highly mobile species, and large coalesced populations periodically make major movements in pursuit of preferred food trees (Hall and Richards 2000). They use 'local' flying fox camps as daytime roosts, and typically swell camp numbers from thousands to tens or hundreds of thousands, with a resultant increase in density and physical interaction. Thus, the higher probability of infection in all species in the first half of the year could reflect the seasonal nomadic movements of *P. scapulatus*.

In Megachiroptera, species also appears to be an important risk factor for infection (Field 2005). Of the four common megachiropteran species 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 in other species (Hall and Richards 2000). *P. scapulatus* also undertakes much larger nomadic movements than the other species, potentially increasing the opportunity for exposure (ibid). Finally, the reproductive cycle of *P. scapulatus*, though similar to other *Pteropus* species, is out of phase by 6 months relative to other species (ibid).

Microchiroptera

Species appears to be the only risk factor for infection in Microchiroptera (Field 2005). The prevalence of antibodies indicates that rates of infection are higher in the yellow-bellied sheath-tailed bat (*Saccolaimus flaviventris*) than in other species, suggesting that this species may be important in the maintenance of ABLV in microchiropteran bats. One plausible explanation for the greater prevalence of infection in *S. flaviventris* is that the clinical course is longer in this species. Another possibility is that the fatality rate is lower and/or antibody persistence is longer. Both explanations suggest a special relationship with the virus. This is consistent with the limited molecular studies, which have demonstrated an ABLV variant in *S. flaviventris* 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 microchiropteran 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 in a colony of *Eptesicus serotinus*, another micro-chiropteran species (with titres 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 bats' reproductive cycle (Field 2005).

Captive bat populations

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

In addition there is an extensive wildlife carer network throughout Australia that keeps sick, injured and orphaned bats for rehabilitation, and recovered bats not suitable for release. Typically these bats are kept under a range of conditions in the carers' homes. A few carers maintain large permanent or semi-permanent colonies in large outdoor enclosures.

1.6.1 Incubation period

The available experimental data and data on natural infection indicate that the incubation period for ABLV in bats and humans is similar to that for rabies. The incubation period for rabies is typically from 10 days to several months, and periods of several years have been reported (Smith et al 1991, McColl et al 1993). The incubation period for rabies is influenced by the distance between the site of virus introduction and the central nervous system. In one study using mice, it was shown that the incubation period was shorter and less variable at high doses of ABLV (Barrett 2004).

Bats

The incubation period for ABLV in two naturally infected bats is known from the development of clinical disease in the bats while they were in captivity. In a naturally infected adult flying fox in a captive colony, the time between the putative exposure and the onset of clinical signs was 30 days (Field 2005). In a second natural infection in a juvenile bat that was being hand-raised by a wildlife carer when clinical signs became apparent, the incubation period was estimated at 6–9 weeks (Field et al 1999).

In one study, 3 of 10 *Pteropus poliocephalus* that were experimentally inoculated with ABLV developed clinical disease 15–24 days after inoculation (McColl et al 2002). In an earlier trial conducted at AAHL using a lower dose of inoculum in the same species, 1 of 7 bats developed clinical disease 27 days after inoculation. In another study, 7 of 10 bats developed clinical disease (of 1–4 days duration) between days 10 and 19 after injection. No ABLV was detected in 3 bats that remained well until the end of the experiment on day 82 (Barrett 2004).

Humans

The first human case of ABLV, which was caused by the microchiropteran variant, is believed to have had an incubation period of a few weeks. In the second case, involving the pteropid strain, the incubation period was believed to be 27 months (Hanna et al 2000).

1.6.2   Persistence of agent

Little is known about the persistence of lyssaviruses. For classical rabies virus, the key features relevant to persistence are as follows:

- The virus is comparatively fragile and does not survive for long periods outside the host.

- The virus is stable for several months at 0–4 °C but is rapidly inactivated by heat, direct sunlight and lipid solvents.

- The virus is stable at pH 5–10.

- Infectivity is lost when the virus is treated with proteolytic enzymes.

- The virus survives in saliva for up to 24 hours in temperate climates.

1.6.3   Modes of transmission

Lyssaviruses, including ABLV and rabies virus, are usually transmitted via bites or scratches, which provide direct access of the virus in saliva to exposed tissue and nerve endings.

Although transmission between bats has not been observed, it seems reasonable to deduce, given the nature of bats and the finding of virus in salivary glands, that the virus can be transmitted between bats through biting.

Lyssaviruses have not been found in faeces, which do not appear to pose a risk. ABLV RNA has been detected in a sample of urine from a naturally infected bat (Barrett 2004). However, whether viable virus in urine poses a risk of infection is unclear. Transmission of terrestrial rabies through contact with the urine of an infected animal does not constitute an exposure and is not an indication for prophylaxis.[8]

Aerosol dispersal of saliva containing rabies virus in bat caves has been suggested as a minor mode of transmission between bats, and has been demonstrated experimentally (Baer and Bales 1967). However, the small number of human cases of rabies in speleologists and cavers suggests that aerosol transmission is rare.

Environmental contamination, other than aerosol contamination in bat caves, is of very little significance in transmission of rabies virus, and is presumed to be of negligible significance in the transmission of ABLV.

Until the pathogenesis of ABLV in bats is better understood, other modes of transmission should not be excluded. Further studies on the pathogenesis of ABLV in bats are needed to clarify the dynamics of transmission between bats, and between bats and other animals.

People most often come into contact with sick, injured or orphaned bats, and this subpopulation presents the primary risk of exposure for humans and other terrestrial species. Sick and injured animals — especially those showing clinical signs consistent with encephalitic disease, and yellow-bellied sheath-tailed bats

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[8] www.cdc.gov/rabies/exposure/types.html

and adult little red flying foxes — pose the greatest public health risk, at least to those who come in contact with them, such as veterinarians, veterinary staff and wildlife carers (Field and Ross 1999).

The two human ABLV cases had histories of contact with (Samaratunga et al 1998) and bites from (Hanna et al 2000) clinically ill bats with signs consistent with ABLV infection.

McCall et al (2005) considered the risk of transmission of ABLV from a dog or cat to a person to be very low. They advised that, although an animal may have only a remote possibility of being infected with ABLV, it should be observed and any behavioural changes should be reported.

Veterinary practitioners and their staff who handle sick, injured or orphaned animals are at high risk of exposure to ABLV. Laboratory staff working with any samples (other than faeces) from positive cases are also at high risk.

Assessment of the potential for secondary transmission of ABLV from a non-bat species requires further studies on the ability of ABLV to infect Australian domestic and wild carnivore species. This will enable public health officials to make more confident assessments of the risk of human ABLV infection associated with a bite from an exposed dog or cat (McCall et al 2005).

1.7   Manner and risk of introduction to Australia

ABLV is endemic in the bat population of Australia.

1.8   Social and economic effects

The occurrence of ABLV in Australia has had minimal social and economic effects. If ABLV occurred in a dog, cat or livestock species, social and economic effects would result from the potential for secondary transmission to humans.

Ongoing occurrence in bats is expected to have minimal consequences.

1.9   Criteria for proof of freedom

Testing to date has demonstrated that the virus is widely distributed in wild bat populations in Australia. Therefore, eradication is not an option.

2 Principles of control and eradication

2.1 Critical factors assessed in formulating response policy

Management of Australian bat lyssavirus (ABLV) in wild bats is not feasible. In Australia, species of megachiropteran and microchiropteran bats are widespread and are protected.

Although there may be a short-term benefit, there is no evidence that host control, of wild bats or any other wildlife, has a significant effect on the long-term incidence of lyssaviruses.

Management of transmission of infection to non-bat species (eg humans and domestic animals) should be based on reducing exposure to animals, particularly bats, that are potentially infected with ABLV.

Extrapolation from other lyssaviruses suggests that occasional infection of non-bat species with ABLV is possible; however, establishment of an endemic infection cycle of ABLV in non-bat species appears unlikely.

It is presumed that, if an animal of a non-bat species developed clinical disease due to ABLV infection, that animal would have the potential to transmit ABLV to humans and other animals.

There is no definitive evidence that ABLV can be transmitted to animals other than bats and humans or that aberrant hosts pose a risk of transmission to humans.

Rabies vaccines and immunoglobulins — generated from classical rabies strains — are the only preparations currently available to protect against lyssaviruses. Extrapolation from other lyssaviruses suggests that rabies vaccine may be effective in managing ABLV in humans via pre-exposure and post-exposure protocols, but rabies vaccines have not been validated for use against ABLV. As well, little information is available on the efficacy of rabies immunoglobulin for treatment of ABLV in humans or animals, and the neutralising antibody titre required to confer protection is not known.

Post-exposure vaccination may assist in managing the risk of secondary transmission of ABLV from high-risk animals (eg domestic dogs or cats), potentially exposed to ABLV, to other animals including humans.

Vaccination of wild bats against ABLV is not feasible due to the absence of an effective delivery method. The efficacy of rabies vaccine in bats to protect against ABLV is also unknown.

Current information indicates that the disease in mammals, other than in bats, is invariably fatal.

Due to welfare, social, or financial impacts, or the value of the animal, the threat of euthanasia may deter owners of domestic animals from reporting potential exposure or suspicion of disease, particularly if the animal is clinically healthy.

Where informal quarantine is prolonged, owner compliance is expected to decline.

2.1.1 Risk category of bats

Bats can be categorised based on their potential to transmit ABLV to humans and other animals (ie potential for an infected bat to have infectious contact with a human or other animal). These categories are listed from highest to lowest urgency for action:

- **Category 3** (high human health risk). Bat that is known or reasonably suspected to have had potentially infectious contact with a human (eg has bitten or scratched a person). Within Category 3, bats with clinical signs suggestive of ABLV (see Table 1.2) are of highest risk.

- **Category 2** (high animal health risk, medium human health risk). Bat that poses a potential risk of infection to humans. Disease investigation and exclusion testing is recommended due to either:

  – history or clinical signs suggestive of ABLV without a history of a potentially infectious contact with a human (Category 2a)

  – history of known or suspected contact with another animal (other animal potentially exposed to ABLV via bat) (Category 2b).

- **Category 1** (low risk). Bat that is neither Category 2 nor Category 3 — that is, bat that has no history of known or suspected contact with another animal or person and for which the index of suspicion for ABLV infection is low (eg no clinical signs consistent with ABLV) (see Table 1.2).

2.2 Options for control and eradication based on the assessed critical factors

There are no options for control or eradication of ABLV in wild bat populations.

A risk-based approach could be used to determine the most appropriate policy option. Issues to be considered include:

- Is there evidence the bat had ABLV (including test result for the bat and/or clinical signs and history of the bat)?

- Is there evidence that any ABLV in the bat could have been transmitted (potential for exposure of dogs or cats to the bat)?

- Is there evidence that the other animal has ABLV (any clinical signs observed in the dog or cat)?

Based on the critical factors and the risk assessment, the policy options for control and eradication of ABLV in animals (other than wild bats) potentially exposed to ABLV include:

- pre-exposure rabies vaccination in the event of an outbreak;

- post-exposure rabies vaccination with serological verification of vaccination response;

- clinical monitoring during formal or informal quarantine; and

- euthanasia.

The policy to be implemented is described in Section 3.

2.2.1 Control of ABLV in wild and feral mammals

There have been no confirmed reports of the establishment of ABLV infection in terrestrial mammalian species other than humans. However, since there have been overseas reports of other lyssaviruses spilling over to non-bat species, active surveillance of wild and feral mammals may be appropriate. In the unlikely event that ABLV was being maintained in wild and feral mammals, overseas experience suggests that oral vaccination using modified rabies virus baits may be useful to control ABLV in such animals.

2.2.2 Control of ABLV in captive bats

Where bats are housed together for prolonged periods, and bats are moving into and out of a group (for example in some creche situations), the likelihood of ABLV infection in the colony will increase. In these situations, biosecurity should be maintained. This might include the use of enclosures that exclude contact with (and potential infection from) wild bats (eg double-mesh enclosures) and 'all-in-all-out' management.

In particular, bats with clinical signs consistent with ABLV infection brought into care should be quarantined from all other bats until the situation is resolved.

The potential to prevent human exposure to clinical ABLV by vaccination of bats in temporary care is low.

2.2.3 Management of in-contact domestic animals

The options for managing in-contact domestic animals depend on whether the animals can become infected with ABLV (from bats), and the risk of secondary transmission to humans. These animals are most likely to be dogs or cats.

There are three likely scenarios to be managed:

- Animal has contact with a bat for which there is a confirmed diagnosis of lyssavirus or ABLV.
- Animal has contact with a potentially infected bat for which there is no test result:
  - History of the bat is suggestive of ABLV (based on consideration of the risk factors for ABLV infection — age, species and the presence of central nervous system clinical signs suggestive of ABLV).
  - History of the bat is not suggestive of ABLV — the animal is clinically normal and is unlikely to have been exposed to ABLV previously (eg clinically well bat kept in exclusion enclosure as part of a permanent closed colony).
  - No history; no assessment of the likelihood that the bat has ABLV is possible.
- Animal has contact with a bat confirmed ABLV negative.

2.2.4　Management options for domestic animals

Where the bat has been confirmed as ABLV negative, it can be assumed that no exposure has occurred. No further management would be required.

In all other cases, the key management options for a potentially exposed animal are as follows.

Post-exposure vaccination with rabies vaccine

Although there is no definitive information on efficacy, post-exposure vaccination may be an option in animals where the timing of vaccination in relation to exposure allows for a sufficient response and subclinical resolution before the onset of clinical disease. It is possible that a vaccinated infected animal will develop clinical ABLV disease before developing an effective response to the vaccine.

Contact of the post-exposure vaccinated animal with other animals or people should be minimised until the vaccination protocol has been completed.

Clinical monitoring (formal or informal quarantine)

Formal quarantine involves keeping the animal under regulated biosecurity conditions.

Informal quarantine requires confinement of the animal. The owner is required to seek immediate veterinary advice if the animal show signs consistent with ABLV.

This management option is based on the lack of evidence of naturally occurring ABLV infection in domestic animals and the lack of symptomatic ABLV in experimentally infected dogs and cats.

Although the likelihood of an animal contracting and transmitting ABLV is considered very low, this management option does not reduce the potential for the exposed animal to develop clinical disease.

Euthanasia

Euthanasia of the potentially exposed animal removes the risk of secondary transmission.

2.2.5　Management of human exposure to ABLV

For management of human health risks from ABLV, information documents prepared by the Communicable Diseases Network Australia should be consulted.[9]

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[9] Information for veterinarians, members of the public and medical practitioners can be found at www.health.gov.au/internet/main/publishing.nsf/Content/cda-pubs-other-bat_lyssa.htm

3 Policy and rationale

3.1 Introduction

Australian bat lyssavirus (ABLV) is endemic in the bat population of Australia, and the potential for spread to domestic animals and humans is of concern. No case of ABLV infection in a domestic animal has been reported, but there have been two human fatalities.

ABLV is a Category 1 disease under the government–industry Emergency Animal Disease (EAD) Response Agreement for cost-sharing arrangements. Category 1 diseases are those for which the costs will be borne 100% by governments.

The policy to address the risks presented by ABLV is to manage at-risk domestic animals and captive wildlife, and the associated risks to humans, using a combination of strategies including:

- *monitoring* of domestic animals (in particular, dogs and cats) potentially exposed to bats and seeking veterinary intervention if the animal becomes ill or exhibits behavioural changes;

- *testing* for ABLV in domestic animals (in particular, dogs and cats) showing neurological or behavioural signs suggestive of rabies-like illness; notification of results to the state or territory chief veterinary officer;

- *testing* of available bats that show signs consistent with ABLV, and bats having contact with humans and/or domestic animals (where the bat is available for testing); notification of results to the state or territory chief veterinary officer;

- a recommendation to *euthanase* the in-contact animal(s) if the bat tests positive to ABLV and the in-contact animal(s) exhibit clinical signs or behavioural changes; animals should also be euthanased if requested by the owner;

- if such an animal is not euthanased, a recommendation to *quarantine* in-contact animal(s) if the bat tests positive to ABLV and the in-contact animal(s) exhibit clinical signs or behavioural changes;

- immediate post-exposure *vaccination* of domestic and captive animals that do not show clinical signs or behavioural changes but have had contact with a positive-test-result bat, a bat with a history suggestive of ABLV, or a bat for which no history is available;

- a continuing *public awareness campaign* to educate and foster cooperation from the community;

- ongoing *disease investigation and surveillance* of bat species to elaborate disease ecology and epidemiology, and assist in risk assessment; and

- *targeted surveillance* if ABLV is found in a non-bat species.

The chief veterinary officer (CVO) and chief medical officer (CMO) (or equivalent) in the state or territory in which infection in domestic animals is demonstrated are responsible for implementing disease control measures in accordance with relevant legislation. CVOs and CMOs will make ongoing decisions on follow-up disease control measures in consultation with the Consultative Committee on Emergency Animal Diseases (CCEAD), the state and territory governments and the Australian Government. The detailed control measures adopted will be determined using the principles of control and eradication (Section 2) and epidemiological information about the outbreak.

For information on the responsibilities of the state or territory disease control headquarters and local disease control centres, see the **Control Centres Management Manual**.

3.2 Control and eradication policy

Eradication of ABLV from the bat population is not feasible.

The ABLV status of any bat having direct contact with domestic animals (particularly dogs and cats) and captive wildlife will be determined if the bat is available.

The policy to address the risks presented by ABLV is to manage at-risk domestic animals (particularly dogs and cats) and captive wildlife, and the associated risks to humans using a combination of strategies including:

- monitoring of animals potentially exposed to bats;

- seeking veterinary treatment if the animal becomes ill or exhibits behavioural changes;

- immediate post-exposure vaccination to manage animals not showing clinical signs or behavioural changes but that have had contact with a positive-test-result bat, a bat with a history that suggests the bat has ABLV, or a bat with no history available

  - post-exposure vaccination will only be used with the permission of the state or territory CVO (in consultation with CCEAD)

  - serological testing of the animal being vaccinated is recommended to demonstrate a response to vaccination

  - contact with the animal should be minimised until 3 weeks after the second vaccination; and

- other management options such as euthanasia or quarantine — these are recommended only if the bat tests positive to ABLV and the animal becomes ill or exhibits behavioural changes.

3.2.1 Stamping out

Stamping out is not applicable to ABLV.

Euthanasia of clinically healthy animals, although effective at eliminating the potential for transmission of ABLV, may not be acceptable to the animal owner or carer. It may discourage future reporting of potential exposure to ABLV.

Animals with a history and clinical signs leading to a high index of suspicion of ABLV infection should be ethanased and tested.

3.2.2 Quarantine and movement controls

Informal quarantine is not effective for healthy animals due to poor owner compliance. Formal quarantine is not justified due to high costs, welfare impacts, and lack of appropriate facilities or staff.

The cost of formal quarantine may be justified for short periods if an animal becomes unwell or exhibits behavioural changes that require differentiation from ABLV.

In captive bat colonies, any bat exhibiting clinical signs consistent with ABLV infection should be immediately isolated and subject to expert veterinary examination. If no clear diagnosis can be made, the bat should be euthanased and tested for ABLV infection.

If the virus was found in a captive bat colony, quarantine and movement controls will be imposed until future management of the colony has been decided and implemented — for example, implementation of a vaccination program and demonstration of a protective titre.

3.2.3 Tracing and surveillance

Tracing of wild bat movements is not feasible.

Domestic animals and captive bats in direct contact with a bat or other animal that has been confirmed as lyssavirus or ABLV positive in the previous 7 days, or that shows clinical signs consistent with rabies or ABLV infection, will be traced and placed under surveillance.

Following diagnosis of ABLV in a non-bat animal, increased surveillance of local mammals may be undertaken. This may include risk-based surveillance of bat colonies to provide information to reduce human exposure to ABLV. Where there is a cluster of cases of ABLV, there will be value in investigating bat movements for the same reason.

3.2.4 Disposal

The best method of disposal of dead bats is by incineration. If incineration is not possible, burial is the next best option. (See the **Operational Procedures Manual — Disposal.)**

Disposal of animal products is not applicable for ABLV.

3.2.5 Decontamination

ABLV is inactivated by most organic solvents, oxidising agents, and surface-active agents (quaternary ammonium compounds, soaps and detergents) (see Section 1.6.2). Oxidising agents such as hypochlorite may be used for environmental decontamination, and Virkon® can be used on inanimate objects. Quaternary ammonium compounds are also useful for personal disinfection.

If accidental exposure occurs — such as when a person is bitten by a bat, or bat saliva contacts the hands or face — first aid measures should be applied immediately to remove the pathogen, and the person should seek urgent medical advice. Immediate first aid measures include:

- thorough washing of the wound with soap and water; and

- rapid application of a disinfectant (either an alcoholic or a halide compound).

Proper cleaning of the wound is regarded as the single most effective measure to reduce transmission of lyssaviruses.

As fomites are not infectious, and the virus is highly labile, environmental contamination by infected animals is negligible. No particular environmental disinfection is required, particularly after delays of more than one day. Fresh saliva or other infectious material can be cleaned off with disinfectant or warm soapy water.

For further details, see the **Operational Procedures Manual — Decontamination.**

3.2.6 Zoning and compartmentalisation

Not applicable.

3.2.7 Vaccination

Vaccination of wild bats

No effective vaccine delivery mechanism is available for bat vaccination.

Vaccination of captive bats

The effect of vaccination with rabies vaccine on pre-existing ABLV infections in the colony, and the level and duration of protection offered to the bat by vaccination, are not known. Pre-exposure vaccination of permanent residents of captive bat colonies may be considered based on the risk to keepers, tourists and the general public from exposures to captive bats. However, the emphasis for control of ABLV within captive colonies is on biosecurity, such as the use of exclusion (eg double-mesh) enclosures for housing bats.

Wild bats coming into temporary captive care (eg undergoing rehabilitation by wildlife carers or veterinary treatment) will not generally be vaccinated.

Vaccination of domestic animals

Until studies are done to determine the ability of ABLV to infect terrestrial mammals, pre-exposure vaccination of domestic animal populations is not justified.

Vaccination of a domestic animal with rabies vaccine for protection against ABLV can only be approved by the CVO of the relevant jurisdiction. The effect of post-exposure vaccination on subclinical infections in animals, and the level and duration of protection offered by vaccination, are not known.

Post-exposure vaccination will be considered in managing risks associated with ABLV in domestic animals that do not show clinical signs or behavioural changes

but have had contact with a positive-test-result bat, a bat with a history suggestive of ABLV infection (where no test result is available), or a bat for which no history is available.

Pre-exposure vaccination protocol

The vaccine manufacturer's instructions for rabies should be followed when rabies vaccine is used for pre-exposure protection against ABLV infection.

Post-exposure vaccination protocol

Limited information is available about the efficacy of post-exposure vaccination using rabies vaccine for protection against ABLV infection. However, the following is an example of a protocol:

- Vaccinate at day 0 and day 7 (day 0 should be as soon as possible after putative exposure to ABLV).

- Assess response to the vaccine between days 21 and 28. Demonstration of a serological response to the vaccine of at least 2 IU/mL is required. If the titre is less than 2 IU/mL, vaccinate again and retest.

- Limit human and animal contact with the vaccinated animal, and monitor the vaccinated animal's clinical status for a further 3 weeks after validation of a titre of at least 2 IU/mL.

- Where the titre is not at least 2 IU/mL or test results are not available, limit contact and monitor for a further 21 days after testing for the second vaccinal titre.

- If the animal becomes unwell before the end of the monitoring period, quarantine it until the situation is clarified, or euthanase it and test for ABLV infection.

This protocol is based on limited information and likely to be modified as more data become available. However, a dog that does not demonstrate a titre of >2.0 IU/mL cannot be considered as protected from infection and cannot be considered as unable to transmit ABLV. Although the incubation period for rabies is variable, there is evidence that 50% of infected dogs demonstrate disease within 4 months and a further 25% within 8 months. This may assist when considering the management of dogs exposed to ABLV who fail to demonstrate an acceptable titre after vaccination.

3.2.8 Treatment of animal products

Virus transmission through animal products and byproducts is not likely.

Urine or saliva splashes on animal products should be immediately and thoroughly washed with soap and water.

Treatment of fruit

Fruit could be contaminated by contact with saliva and urine of infected bats. As 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. However, fruit freshly picked from trees inhabited by bats should be washed with soap and water before eating, even if there is no sign of damage by bats.

3.2.9   Treatment of infected animals

There is no effective treatment for clinically affected animals.

Rabies immunoglobulin, with or without vaccination, may be effective in preventing disease. However, its use in Australia is limited to the treatment of humans.

Destruction of animals

Bats in small cages or bags can be killed with minimal risk to handlers by enclosing the cage or bag in a plastic bag and using gaseous anaesthetic agents.

Bats may be also be anaesthetised using anaesthetic gas prior to euthanasia. This would be feasible, for example, if the bat, 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 adminster 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 vaccinated against rabies.

Where the animal can be safely confined (for example, in a crush cage), restrained in a bag, or held by a skilled, vaccinated and appropriately trained assistant wearing appropriate protective clothing, an intravenous or diluted intraperitoneal barbiturate overdose may also be administered by a veterinarian vaccinated against rabies.

If a bat must be killed with a firearm, shooting it through the head should be avoided because the brain will be needed for diagnostic confirmation, and dispersal of brain material may pose a safety risk.

3.2.10   Wild animal and vector control

Destruction of wild bats or their habitat is not warranted or effective.

No lyssaviruses are spread by vectors. Control of vectors is therefore not necessary.

3.2.11   Public awareness and media

Periodic awareness programs, strategically timed to coincide with times of increased bat diagnostic submissions (reflecting increased human contact), will be considered to keep the public informed about the risk of ABLV infection in humans and domestic animals. This activity is ongoing.

3.2.12   Public health implications

There have been two human fatalities caused by ABLV.

3.3   Occupational health and safety

Section 3.3 is awaiting endorsement by CDNA

For management of human health risks from ABLV, information prepared by the Communicable Diseases Network Australia should be consulted.[10]

3.3.1   Human exposure to ABLV

Whenever people are suspected of being exposed to ABLV — for example, by a bite or scratch from a bat — first aid must commence at once to remove any virus from exposed tissue.

Medical advice should be sought immediately, whether or not the person has been vaccinated against rabies.

First aid and medical assessment — bites, scratches and splashes

Thorough cleansing of any wounds, scratches or splashes caused by bats or flying foxes is an important first aid measure in the prevention of ABLV infection in people.

If a person is bitten or scratched, or if existing wounds are splashed with any body fluids from the animal, the affected area should be immediately and thoroughly washed with soap and water (eg for approximately 5 minutes). Scrubbing should be avoided, as this may cause abrasions that could facilitate entry of the virus into the wound. A virucidal antiseptic such as povidone–iodine, iodine tincture, aqueous iodine solution or alcohol (ethanol) should be applied to wounds after washing.

If eyes, nose or mouth are exposed to the animal's body fluids, the area should be flushed thoroughly with water.

In all cases, medical advice should be sought immediately, irrespective of rabies vaccination status, as a booster dose(s) may be necessary (NHMRC 2008).

3.3.2   Procedures for handling animals

Only appropriately vaccinated and trained personnel should handle bats, or animals, tissues, excretions or products that are suspected of being infected with ABLV. (Vaccination of people is discussed in Section 1.5.3.)

All bats and any sick, live animals suspected of being infected with ABLV should be approached and handled only when using protective equipment.

Further details about procedures for handling bats are available from the Communicable Diseases Network Australia. [11]

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[10] Information for veterinarians, members of the public and medical practitioners can be found at
www.health.gov.au/internet/main/publishing.nsf/Content/cda-pubs-other-bat_lyssa.htm
[11] www.health.gov.au/internet/main/publishing.nsf/Content/cda-pubs-other-bat_lyssa.htm

Destroyed animals and their excretions and secretions should be handled with care, and while wearing appropriate personal protective equipment, to avoid potential exposure to live virus through abraded skin or mucous membranes (eg eyes and mouth).

3.4   Other policies

ABLV infection is established in the Australian bat population across a wide area of Australia.

In the unlikely event that ABLV became established in non-bat domestic or wild animals, parenteral vaccination or oral vaccination using modified rabies virus baits is the preferred approach to ABLV control. Vaccination strategies would need to be developed and implemented. (Refer to the **Disease Strategy** for rabies.)

3.5   Funding and compensation

In Australia, ABLV is included as a Category 1 emergency animal disease in the EAD Response Agreement. Category 1 diseases are emergency animal diseases that predominantly seriously affect human health and/or the environment (depletion of native fauna) but may have only minimal direct consequences for the livestock industries. For this category, the costs will be borne 100% by governments, with no contribution from livestock industries (refer to the EAD Response Agreement for details).[12]

ABLV would only be fully covered by cost-sharing funding if it were considered that containment or eradication of the disease from domestic or captive animals, in accordance with this strategy, was possible or appropriate. Otherwise, operational funding would come from state and territory resources.

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[12] www.animalhealthaustralia.com.au/programs/eadp/eadra.cfm

4 Recommended quarantine and movement controls

Because ABLV agent is endemic in Australian bat populations, movement controls are not applicable, except for management of the risks under specific circumstances (see Section 3.2.2).

If species other than bats became infected, the movements controls in the **Disease Strategy** for rabies would be relevant.

Appendix 1 A guide to identifying the common megachiropteran bats

The Megachiroptera are tailless bats with fox-like faces. The first digit on the wing is elongated and has a claw. The second digit also has a claw, which is used as a climbing aid.

The following points may be used as a key to identify the common species.

(1) Upper surface of lower legs thickly furred   go to point (2)

   Upper surface of legs naked   go to point (3)

(2) Forearm length over 130 mm; rusty yellow fur completely encircling neck; head greyish = **grey-headed flying fox (*Pteropus poliocephalus*)**.

(3) Forearm length over 145 mm   go to point (4)

   Forearm length less than 145 mm; reddish brown; light brown – yellow fur around the neck and shoulders; occasional pale fur around eyes = **little red flying fox (*Pteropus scapulatus*)**.

(4) Prominent creamy-yellow fur around eyes; fur blackish; found in coastal north Queensland = **spectacled flying fox (*Pteropus conspicillatus*).** No eye rings; fur black with light tips; reddish area of fur on back of neck = **black flying fox (*Pteropus alecto*)**.

(Adapted from Hall LS and Richards GC (1979). *Bats of Eastern Australia*, Queensland Museum Booklet No. 12, Queensland Museum.)

Appendix 2 Classification of the *Lyssavirus* genus

The *Lyssavirus* genus contains a number of viruses that have the potential to cause rabies or rabies-like disease in humans and other animals. Seven genotypes are currently recognised. ABLV is classified within genotype 7.

Name	Genotype designation	Locality	Principal hosts	Spillover hosts reported
Rabies virus	1	Worldwide (with exceptions) Bat variants are confined to the American continents: insectivorous bat strains mainly in North America, haematophagous bat rabies in South and Central America and the Caribbean.	Multiple American insectivorous bats: highest frequency in *Eptesicus fuscus*, *Lasionycteris noctivagens*, *Lasiuris* spp., *Myotis* spp., *Pipistrellus* spp., *Tadarida brasiliensis* Haematophagous (vampire) bats: *Desmodus* spp.	Insectivorous bat strains to human, fox, skunk. Vampire bat rabies mainly to cattle, horse, human.
Lagos bat virus	2	Sub-Saharan Africa. One case from France in a fruit bat imported from West Africa (1999).	Fruit bats: *Eidolon helvum*, *Micropterus pusillus*, *Epomophorus wahlbergi* Single isolate from insectivorous bat: *Nycteris gambiensis*	Cat, dog, *Atilax paludinosus* (water mongoose)
Mokola virus	3	Sub-Saharan Africa	Not known. Has been isolated from shrews (*Crocidura* spp.)	Cat, dog, human, shrew
Duvenhage virus	4	Southern and East Africa	Insectivorous bats: *Nycteris thebaica*, possible *Miniopterus schreibersi*	Human
European bat lyssavirus 1	5	Europe (continental)	Insectivorous bats, particularly *Eptesicus serotinus*	Sheep, stone marten (*Martes foina*), cat, human
European bat lyssavirus 2	6	Europe (continental, UK)	Insectivorous bats, particularly *Myotis daubentonii*, *Myotis dasycneme*	Human
Australian bat lyssavirus	7	Australia	Flying foxes (*Pteropus* spp.) Insectivorous bat: *Saccolaimus flaviventris*	Human
Aravan, Khujand, Irkut, West Caucasian bat virus	Undesignated. Proposed new genotypes.	Central Asia	Single isolates from insectivorous bats: *Myotis blythi* (Aravan virus), *Myotis mystacinus* (Khujand virus), *Murina leucogaster* (Irkut virus), *Miniopterus schreibersi* (West Caucasian bat virus)	None recorded

Appendix 3 Bat species tested in ABLV infection surveys in Australia

To date, surveillance of bats in Australia has covered only a limited number of bat species, with a large variation of sampling intensity (individuals tested per species). Australia has 13 Megachiroptera species and approximately 63 Microchiroptera species (Hall and Richards 2000). An absence of evidence of infection in the majority of species does not equate to evidence of absence of infection.

The bat species that have been tested for ABLV in Australia are listed below. Despite serological evidence of past infection in most genera tested, ABLV has only been detected in four species of *Pteropus* (*P. alecto*, *P. poliocephalus*, *P. scapulatus* and *P. conspicillatus*) and *Saccolaimus flaviventris* using at least one of fluorescent antibody test, immunoperoxidase staining, polymerase chain reaction, or virus isolation. All other cases were considered negative according to the case definition (see Table 1.4). For more recent information, see the National Wildlife Health Information System database, eWHIS. [13]

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[13] www.wildlifehealth.org.au

	Bat species tested for ABLV in Australia (to Feb 2009)	Status
Megachiroptera	Fruit bats *(*Pteropodidae*)*	
	Pteropus alecto (black flying fox)	+
	Pteropus poliocephalus (black flying fox)	+
	Pteropus scapulatus (grey-headed flying fox)	+
	Pteropus conspicillatus (spectacled flying fox)	–
	Nyctimeme robinsoni (eastern tube-nosed bat)	+
	Syconycteris australis (common blossom bat)	–
Microchiroptera	Sheath-tailed bats *(*Emballonuridae*)*	
	Saccolaimus flaviventris (yellow-bellied sheath-tailed bat)	+
	Taphozous georgianus (coastal sheath-tailed bat)	
	Leafnosed bats *(*Hipposideridae*)*	
	Hipposideros ater (dusky leafnosed bat)	–
	Freetail bats *(*Molossidae*)*	
	Mormopterus beccarii (Beccar's freetail bat)	–
	Mormopterus loriae (little northern freetail bat)	–
	Nyctinomus australis (white-striped freetail bat)	–
	Chaerophon jobensis (northern freetail bat)	–
	Horseshoe bats *(*Rhinolophidae*)*	
	Rhinolophus philippinensis (subspecies not stated)	–
	Rhinolophus megaphyllus (eastern horseshoe bat)	–
	Evening bats *(*Vespertilionidae*)*	
	Chalinolobus gouldii (Gould's wattled bat)	–
	Chalinolobus morio (chocolate wattled bat)	–
	Chalinolobus nigrogriseus (hoary wattled bat)	–
	Miniopterus schreibersii (large bentwinged bat)	–
	Miniopterus scotorepens	–
	Miniopterus australis (little bentwinged bat)	–
	Nyctophilus bifax (northern long-eared bat)	–
	Nyctophilus geoffroyi (lesser long-eared bat)	–
	Nyctophilus gouldi (Gould's long-eared bat)	–
	Scotorepens orion (eastern broadnosed bat)	–
	Vespadelus spp.	–
	Falsistrellus spp.	–
	Megadermatidae	
	Macroderma gigas (ghost bat)	–

Source: Field (2005); CSIRO-AAHL, unpublished data; Queensland Department of Health 'Bat Stats' database (G Smith, pers comm, November 2006)

Appendix 4 Notes on clinical signs of ABLV in a grey-headed flying fox

The following observations from a wildlife carer's notes show the observed 24-hour clinical course of ABLV infection in an adult grey-headed flying fox (Field 2005; see also Table 1.2). Note that this is a single case record and not all ABLV-infected bats have similar clinical signs.

22/11/00

- 10:00 am: observed to be hanging alone, 'hunching up', and vocalising as if in pain.

- 10:30 am–1.00 pm: continually licking vulva and lower spinal area.

- 1:00 pm: veterinary examination inconclusive; a tentative diagnosis of cystitis made, antibiotics and nonsteroidal anti-inflammatory drugs administered.

- 2:00–4:00 pm: not her normal withdrawn self; taking pieces of fruit aggressively; vocalisation (in the absence of any observed spasms), agitation and aggression getting progressively worse.

- 4:00 pm: moved to another carer; very agitated and very vocal.

- 6:00 pm: a little quieter, licking at her vulva, frequent muscle spasms; attacking her food bowl.

- 7:30 pm: agitated, seems very stiff but still moving about the cage.

- 7:40 pm: having spasms; no longer hanging from the top of the cage.

- 8:00 pm: moving slowly around the cage; has salivated or urinated on herself; eyes glassy and moist; seems in great pain; vocalising a little and fanning her wings as if hot; still biting her food bowl as she passes it.

- 8:30 pm: seems to be having a seizure; strange vocalisation, salivating profusely, tears streaming.

- 9:00 pm: another seizure; not as vocal but shaking violently.

- 10:00–11:00 pm: two further seizures; very vocal.

23/11/00

- 6:00 am: almost comatose; euthanased and forwarded for diagnostic testing. (Subsequently confirmed ABLV positive.)

Appendix 6 State and territory public health contacts

The following information was correct at the time of publication (5 March 2006).

Additional information may be obtained from
www.healthinsite.gov.au/topics/Health_Services.

State or territory	Agency	Contact details	
ACT	ACT Communicable Disease Control	Phone	02 6205 2155
NSW	Central Coast Public Health Unit	Phone Fax	02 4349 4845 02 4349 4850
	South Eastern Sydney Public Health Unit	Phone Fax	02 9382 8333 02 9382 8334
	Greater Southern Area Health Service — Population Health	Phone Fax	02 6080 8900 02 6021 8999
	Hunter New England Population Health	Phone Fax	02 4924 6499 02 4924 6490
	Illawarra Public Health Unit	Phone Fax	02 4221 6700 02 4221 6759
	Mid North Coast Population Health Unit	Phone Fax	02 6588 2750 02 6588 2837
	New England Public Health Unit (Tamworth)	Phone Fax	02 6767 8630 02 6766 3003
	Northern Sydney Public Health Unit	Phone Fax	02 9477 9400 02 9482 1358
	Western Sector Public Health Unit (Sydney)	Phone Fax	02 9840 3603 02 9840 3608
	Sydney West Area Health Service Centre for Population Health	Phone Fax	02 4734 2022 02 4734 3300
	NSW Health Dept — Head Office (AIDS & Infectious Diseases Branch)	Phone Fax	02 9391 9192 02 9391 9848
NT	Department for Health and Families, Centre for Disease Control — Darwin	Phone Fax	08 8922 8044 08 8922 8310
QLD	Darling Downs Population Health Unit — Toowoomba	Phone Fax	07 4631 9888 07 4639 4772
	Tropical Population Health Unit — Cairns	Phone Fax	07 4050 3600 07 4031 1440
	Tropical Population Health Service — Townsville	Phone Fax	07 4750 4000 07 4753 9001
	Central Queensland Population Health Unit	Phone Fax	07 4920 6989 07 4920 6865
	Central Queensland Population Health Unit — Wide Bay, Harvey Bay	Phone Fax	07 4120 6000 07 4120 6009
	Brisbane Northside Population Health Unit	Phone Fax	07 3624 1111 07 3624 1159
	Sunshine Coast Population Health Unit	Phone Fax	07 5479 4655 07 5443 5488
	Brisbane Southside Population Health Unit	Phone Fax	07 3000 9148 07 3000 9121
	Gold Coast Public Health Unit — Southport	Phone Fax	07 5509 7222 07 5561 1851
	Communicable Diseases Unit, Queensland Health — Brisbane	Phone Fax	07 3234 1155 07 3234 0057
SA	SA Health Department, Communicable Disease Control Branch	Phone Fax	08 8226 7177 08 8224 7187
TAS	Dept of Health and Human Services	Phone	1300 135 513
VIC	Dept of Human Services Victoria (during office hours)	Phone	03 9096 7777
WA	Enviromental Health WA	Phone Fax	08 9388 4999 08 9388 4955

Appendix 7 Features of Australian bat lyssavirus

Disease and cause

Australian bat lyssavirus (ABLV) is endemic in bats in Australia. In humans, the virus causes a fatal encephalitic disease that is indistinguishable from rabies. The disease in bats is also similar to rabies. ABLV has caused the deaths of two people in Australia.

Prevention

Rabies vaccine is given as pre-exposure prophylaxis to people who are occupationally exposed to the virus, and as post-exposure prophylaxis to people who have been bitten or scratched by Australian bats.

Species affected

Evidence of infection with ABLV has been reported in flying foxes and in insectivorous bats in Australia. No cases of ABLV infection in Australian mammals other than bats have been reported. There is some evidence to support the possibility of subclinical or mild clinical ABLV infection in dogs under experimental conditions. The situation in cats and other mammals is less clear, but they probably can also become infected.

Distribution

ABLV-infected bats have been reported from the northern and eastern coastal areas of Australia. Serological evidence suggests a wide geographical distribution in bats in Australia. The prevalence of ABLV infection in clinically normal, wild-caught Australian bats is extremely low.

Key signs

Bats affected with ABLV show a range of clinical signs, including overt aggression, paresis and paralysis, seizures and tremors, weakness, respiratory difficulties, and change of voice. ABLV must also be considered in dead or moribund bats, or those that appear to be suffering from another disease**. Clinical signs are so variable that ABLV infection should be considered when handling any bat, especially if it is sick, injured or unable to fly.**

Spread

Lyssaviruses including ABLV and rabies virus are usually transmitted between animals via bites or scratches, which provide direct access of the virus in saliva to exposed tissue and nerve endings. Transmission is poorly understood for ABLV and, until pathogenesis is better understood, other modes of transmission should not be excluded.

Persistence of the agent

Little is known about the persistence of ABLV. The closely related classical rabies virus is comparatively fragile and does not survive for long periods outside the host.

Glossary

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, hooves, bones, fertiliser).
Animal Health Committee	A committee comprising the CVOs of Australia and New Zealand, Australian state and territory CVOs, Animal Health Australia, and a CSIRO representative. The committee provides advice to PIMC on animal health matters, focusing on technical issues and regulatory policy (formerly called the Veterinary Committee). *See also* Primary Industries Ministerial Council (PIMC)
Animal products	Meat, meat products and other products of animal origin (eg eggs, milk) for human consumption or for use in animal feedstuff.
Australian Chief Veterinary Officer	The nominated senior veterinarian in the Australian Government Department of Agriculture, Fisheries and Forestry who manages international animal health commitments and the Australian Government's response to an animal disease outbreak. *See also* Chief veterinary officer
AUSVETPLAN	Australian Veterinary Emergency Plan. A series of documents that describe the Australian response to emergency animal diseases, linking policy, strategies, implementation, coordination and emergency management plans.
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. *See also* Australian Chief Veterinary Officer
Compensation	The sum of money paid by government to an owner for stock that are destroyed and property that is compulsorily destroyed because of an emergency animal disease. *See also* Cost-sharing arrangements, Emergency Animal Disease Response Agreement
Consultative Committee on Emergency Animal Diseases (CCEAD)	A committee of state and territory CVOs, representatives of CSIRO Livestock Industries and the relevant industries, and chaired by the Australian CVO. CCEAD convenes and consults when there is an animal disease emergency due to the introduction of an emergency animal disease of livestock, or other serious epizootic of Australian origin.

Cost-sharing arrangements	Arrangements agreed between governments (national and states/territories) and livestock industries for sharing the costs of emergency animal disease responses. *See also* Compensation, Emergency Animal Disease Response Agreement
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 slaughter 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.
Disposal	Sanitary removal of animal carcases, 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 has met one or more of the following criteria:

- A known disease that does not occur in endemic form in Australia and for which it is considered to be in the national interest to be free of the disease.

- A variant form of an endemic disease, which is itself not endemic, caused by a strain or type of the agent that can be distinguished by appropriate diagnostic methods, and which, if established in Australia, would have a national impact.

- A serious infectious disease of unknown or uncertain cause, which may, on the evidence available at the time, be an entirely new disease.

- A known endemic disease occurring in such a fulminant outbreak form (far beyond the severity expected) that an emergency response is required to ensure that there is neither a large-scale epidemic of national significance nor serious loss of market access.

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 funding mechanisms, the use of appropriately trained personnel and existing standards such as AUSVETPLAN. *See also* Compensation, Cost-sharing arrangements
Endemic animal disease	A disease affecting animals (which may include humans) that is known to occur in Australia. *See also* Emergency animal disease, Exotic animal disease
Enzyme-linked immunosorbent assay	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.
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.
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.
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 the pathogen into the animal and the first clinical signs of the disease.
Local disease control centre	An emergency operations centre responsible for the command and control of field operations in a defined area.
Movement control	Restrictions placed on the movement of animals, people and other things to prevent the spread of disease.
National management group (NMG)	A group established to direct and coordinate an animal disease emergency. NMGs may include the chief executive officers of the Australian Government and state or territory governments where the emergency occurs, industry representatives, the Australian CVO (and chief medical officer, if applicable) and the chairman of Animal Health Australia.
OIE Code	*Terrestrial Animal Health Code* (updated each May and published on the internet at www.oie.int).

Outbreak	The occurrence of one or more cases of a disease or an infection in animals in a common environment.
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.
Primary Industries Ministerial Council (PIMC)	The council of Australian national, state and territory and New Zealand ministers of agriculture that sets Australian and New Zealand agricultural policy (formerly the Agriculture and Resource Management Council of Australia and New Zealand). *See also* Animal Health Committee
Prophylactic	Treatment administered prospectively to prevent the onset of disease.
Quarantine	Legal restrictions imposed on a place or a tract of land by the serving of a notice limiting access or egress of specified animals, persons or things.
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.
Serotype	A subgroup of microorganisms identified by the antigens carried (as determined by a serology test).
Stamping out	Disease eradication strategy based on the quarantine and slaughter of all susceptible animals that are infected or exposed to the disease.
State or territory disease control headquarters	The emergency operations centre that directs the disease control operations to be undertaken in that state or territory.
Surveillance	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.
Susceptible animals	Animals that can be infected with a particular disease.
Suspect animal	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; OR an animal not known to have been exposed to a disease agent but showing clinical signs requiring differential diagnosis.

Tracing	The process of locating animals, persons or other items that may be implicated in the spread of disease, so that appropriate action can be taken.
Vaccination	Inoculation of healthy individuals with weakened or attenuated strains of disease-causing agents to provide protection from disease.
Vaccine	Modified strains of disease-causing agents that, when inoculated, stimulate an immune response and provide protection from disease.
Vector	A living organism (frequently an arthropod) that transmits an infectious agent from one host to another. A *biological* vector is one in which the infectious agent must develop or multiply before becoming infective to a recipient host. A *mechanical* vector is one that transmits an infectious agent from one host to another but is not essential to the life cycle of the agent.
Wild animals	
– native wildlife	Animals that are indigenous to Australia and may be susceptible to emergency animal diseases (eg bats, dingoes, marsupials).
– feral animals	Domestic animals that have become wild (eg cats, horses, pigs).
– exotic fauna	Nondomestic animal species that are not indigenous to Australia (eg foxes).
Zoning	The process of defining disease-free and infected areas in accord with OIE guidelines, based on geopolitical boundaries and surveillance, in order to facilitate trade.
Zoonosis	Diseases or infections that are naturally transmitted between vertebrate animals and humans.

Abbreviations

AAHL	CSIRO Australian Animal Health Laboratory
ABLV	Australian bat lyssavirus
CCEAD	Consultative Committee on Emergency Animal Diseases
CMO	chief medical officer
CNS	central nervous system
CVO	chief veterinary officer
EAD	emergency animal disease
FAT	fluorescent antibody test
HDCV	(rabies) human diploid cell vaccine
OIE	World Organisation for Animal Health (formerly Office International des Epizooties)
PCR	polymerase chain reaction
RFFIT	rapid fluorescent focus inhibition test

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