

AUSTRALIAN VETERINARY EMERGENCY PLAN

AUSVETPLAN

Disease Strategy

Rabies

Version 3.0, 2011

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

This disease strategy forms part of:

AUSVETPLAN Edition 3

This strategy will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to:

AUSVETPLAN — Animal Health Australia
Manager, Veterinary Services
Suite 15, 26–28 Napier Close
Deakin ACT 2600
Tel: 02 6232 5522; Fax: 02 6232 5511
email: admin@animalhealthaustralia.com.au

Approved citation: Animal Health Australia (2011). Disease strategy: Rabies (Version 3.0). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, Primary Industries Ministerial Council, Canberra, ACT.

Publication record:

Edition 1: 1991

Edition 2:

Version 2.0, 1996 (major update)

Edition 3:

Version 3.0, 2011 (major update and inclusion of movement controls matrices)

AUSVETPLAN is available on the internet at:

www.animalhealthaustralia.com.au

© Commonwealth of Australia and each of its states and territories, 2011

ISBN 0 642 24506 1 (printed version)

ISBN 1 876 71438 7 (electronic version)

This work is copyright and, apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced without written permission from the publishers, the Australian Government Department of Agriculture, Fisheries and Forestry and Animal Health Australia, acting on behalf of the Primary Industries Ministerial Council. Requests and inquiries concerning reproduction and rights should be addressed to AUSVETPLAN – Animal Health Australia (see above).

The publishers give no warranty that the information contained in AUSVETPLAN is correct or complete and shall not be liable for any loss howsoever caused, whether due to negligence or other circumstances, arising from use of or reliance on this code.

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 a rabies outbreak in Australia 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**. This rabies 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). The key features of rabies are described in Appendix 1.

This manual has been produced in accordance with the procedures described in the AUSVETPLAN **Summary Document** and in consultation with Australian national, state and territory governments and industry.

Rabies is included on the World Organisation for Animal Health (OIE) list of notifiable diseases as a multiple species disease. This obliges OIE member countries that had been free from the disease to notify the OIE within 24 hours of confirming the presence of rabies. OIE-listed diseases are diseases with the potential for international spread, significant mortality or morbidity within the susceptible species, and/or potential for zoonotic spread to humans.¹

The strategies in this document for the diagnosis and management of an outbreak of rabies are based on the recommendations in the OIE *Terrestrial Animal Health Code*² and the OIE *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*.³

In Australia, rabies 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).⁴

In this manual, 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.

¹ These criteria are described in more detail in Chapter 1.2 of the *OIE Terrestrial Animal Health Code* (www.oie.int/index.php?id=169&L=0&htmfile=chapitre_1.1.2.htm)

² www.oie.int/index.php?id=169&L=0&htmfile=chapitre_1.8.10.htm

³ www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.01.13_RABIES.pdf

⁴ Information about the EAD Response Agreement can be found at www.animalhealthaustralia.com.au/programs/eadp/eadra.cfm

In addition, *Exotic Diseases of Animals: A Field Guide for Australian Veterinarians* by WA Geering, AJ Forman and MJ Nunn, Australian Government Publishing Service, Canberra, 1995 (to be updated) is a source for some of the information about the aetiology, diagnosis and epidemiology of the disease.

AUSVETPLAN manuals⁵

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
- Livestock welfare and management
- Public relations
- Valuation and compensation

Enterprise manuals

- Artificial breeding centres
- Feedlots
- Meat processing
- Saleyards and transport
- Poultry industry
- Zoos

Management manuals

- Control centres management (Parts 1 and 2)
- Laboratory preparedness

Wild animal response strategy

Summary document

⁵ The complete series of AUSVETPLAN documents is available on the internet at: www.animalhealthaustralia.com.au/programs/eadp/ausvetplan/ausvetplan_home.cfm

Contents

Preface	3
1 Nature of the disease.....	8
1.1 Aetiology	8
1.2 Susceptible host species	10
1.3 World distribution and occurrence in Australia.....	11
1.4 Diagnostic criteria	12
1.4.1 Clinical signs	12
1.4.2 Pathology.....	15
1.4.3 Laboratory tests	16
1.4.4 Differential diagnosis.....	21
1.4.5 Treatment of infected animals.....	21
1.5 Resistance and immunity.....	21
1.5.1 Innate and passive immunity	21
1.5.2 Active immunity.....	22
1.5.3 Vaccination.....	22
1.6 Epidemiology	25
1.6.1 Incubation period	26
1.6.2 Persistence of agent.....	26
1.6.3 Modes of transmission.....	27
1.6.4 Factors influencing transmission.....	28
1.7 Manner and risk of introduction to Australia.....	28
2 Principles of control and eradication.....	29
2.1 Critical factors assessed in formulating response strategy	29
2.1.1 Features of the disease.....	29
2.1.2 Vaccination.....	29
2.1.3 Features of the populations.....	30
2.2 Options for control and eradication	30
3 Policy and rationale.....	32
3.1 Introduction.....	32
3.2 Occupational health and safety.....	33
3.2.1 Key points.....	33
3.2.2 Vaccination.....	34
3.2.3 First aid and medical assessment.....	34
3.2.4 Handling of animals.....	35
3.3 Strategy for control and eradication.....	36

3.3.1	Stamping out.....	36
3.3.2	Quarantine and movement controls.....	36
3.3.3	Tracing and surveillance	37
3.3.4	Vaccination.....	38
3.3.5	Treatment of infected animals	39
3.3.6	Treatment of animal products and byproducts	39
3.3.7	Disposal of animal products and byproducts	39
3.3.8	Decontamination	39
3.3.9	Wild animal control	40
3.3.10	Vector control.....	41
3.3.11	Public awareness and media.....	41
3.4	Funding and compensation.....	41
4	Recommended quarantine and movement controls	43
4.1	Guidelines for classifying declared areas and premises.....	43
4.1.1	Declared premises	43
4.1.2	Declared areas.....	43
4.2	Movement controls for rabies.....	44
4.2.1	Declared premises	44
4.2.2	Permit conditions	44
Appendix 1	Key features of rabies	47
Appendix 2	Procedures for surveillance and proof of freedom	50
Glossary		51
Abbreviations		59
References.....		60
Tables		
Table 1.1	Lyssavirus genotypes: common name, numerical genotype classification, geographic location, maintenance hosts and known spillover hosts	9
Table 1.2	Examples of maintenance-host species for rabies virus (genotype 1) biotypes.....	11
Table 1.3	Tests currently available at the CSIRO-AAHL for use in the diagnosis and control of rabies	18
Table 4.1	Movement controls for live susceptible animals.....	46
Table 4.2	Movement controls for vaccinated animals.....	46
Table 4.3	Specific and general permit conditions	46

Figures

Figure 1.1 The current approach to diagnostic testing for rabies used at CSIRO-
AAHL..... 18

1 Nature of the disease

This AUSVETPLAN manual considers only rabies caused by lyssaviruses that are maintained and transmitted in warm-blooded terrestrial animals and bats. Infection with Australian bat lyssavirus is covered in a specific AUSVETPLAN disease strategy manual.

Rabies is a viral encephalitis of mammals that is almost invariably fatal. It is usually transmitted by bites and has a variable incubation period of days to years. Globally, the disease is of both public health and animal health significance.

Although an endemic lyssavirus is present in bats in Australia and can cause a fatal encephalitis – which is indistinguishable from rabies in humans – Australia is free from the rabies virus. Rabies is a disease that is present in most of the world, and is maintained in various hosts such as dogs and other carnivores, and bats.

1.1 Aetiology

Rabies is caused by infection with viruses of the genus *Lyssavirus*, family *Rhabdoviridae*. Lyssaviruses are genetically and serologically related, and all cause similar diseases in mammals. The genus is classified phylogenetically into seven genotypes, with four proposed new genotypes each from central Asian microchiropterid bat (Table 1.1). Lyssavirus genotypes can be further classified into variants or biotypes, defined by their maintenance-host species. A virus biotype is adapted to a single maintenance-host species, where infection and transmission by members of this species are highly efficient. Other species may also be infected by the virus biotype, but these hosts may be too inefficient as vectors or may not be numerous enough to maintain a cycle.

Example of classification:

Family: *Rhabdoviridae*

Genus: *Lyssavirus*

Genotype: for example, classical rabies = genotype 1

Rabies infection in people causes a fatal encephalitic disease. It is a significant public health issue in those areas of the world where it is present. It is virtually always fatal in humans once symptoms appear, and medical advice should be immediately sought if there is a risk of infection.

Table 1.1 Lyssavirus genotypes: common name, numerical genotype classification, geographic location, maintenance hosts and known spillover hosts

Name	Genotype designation	Locality	Maintenance hosts	Spillover hosts reported
Rabies virus	1	Worldwide (with exceptions) Bat biotypes are confined to the American continents — insectivorous bats mainly in North America, haematophagous bats in South and Central America, and the Caribbean.	Multiple American insectivorous bats: highest frequency in <i>Eptesicus fuscus</i> , <i>Lasiorycteris noctivagans</i> , <i>Lasiurus</i> spp., <i>Myotis</i> spp., <i>Pipistrellus</i> spp., <i>Tadarida brasiliensis</i> Haematophagous (vampire) bats: <i>Desmodus</i> spp. Carnivores	Insectivorous bat strains: humans, foxes, skunks Vampire bat rabies: mainly cattle, horses, humans Carnivore rabies: several spillover hosts reported, including cats, dogs, humans, cattle, horses and wildlife
Lagos bat virus	2	Sub-Saharan Africa One case from France in a fruit bat imported from West Africa (1999)	Fruit bats: <i>Eidolon helvum</i> , <i>Micropteropus pusillus</i> , <i>Epomophorus wahlbergi</i> Single isolate from insectivorous bat: <i>Nycteris gambiensis</i>	Cats, dogs, <i>Atilax paludinosus</i> (water mongoose)
Mokola virus	3	Sub-Saharan Africa	Not known. Has been isolated from shrews (<i>Crocidura</i> spp.)	Cats, dogs, humans, shrews
Duvenhage virus	4	Southern and eastern Africa	Insectivorous bats: <i>Nycteris thebaica</i> , possibly <i>Miniopterus schreibersi</i>	Humans
European bat lyssavirus 1	5	Europe (continental)	Insectivorous bats, particularly <i>Eptesicus serotinus</i>	Sheep, stone martens (<i>Martes foina</i>), cats, humans
European bat lyssavirus 2	6	Europe (continental, United Kingdom)	Insectivorous bats, particularly <i>Myotis daubentonii</i> , <i>Myotis dasycneme</i>	Humans
Australian bat lyssavirus	7	Australia	Flying foxes (<i>Pteropus</i> spp.) Insectivorous bat: <i>Saccolaimus flaviventris</i>	Humans
Aravan, Khujand, Irkut, West Caucasian bat virus (WCBV)	Undesignated Proposed new genotypes	Central Asia	Single isolates from insectivorous bats: <i>Myotis blythi</i> (Aravan virus), <i>Myotis mystacinus</i> (Khujand virus), <i>Murina leucogaster</i> (Irkut virus), <i>Miniopterus schreibersi</i> (WCBV)	None recorded

1.2 Susceptible host species

Lyssaviruses infect warm-blooded animals. However, rabies virus (genotype 1) can be further classified into variants or biotypes that have adapted to a specific host species and are referred to as the host biotype. The term biotype, defined by its maintenance-host species, will be used throughout this document for purposes of control and management.

The rabies virus life cycle involves maintenance-host species and spillover-host species:

- *Maintenance host.* The species that principally sustains the virus life cycle is highly susceptible to its biotype, but less susceptible to other biotypes. Successful control of rabies in the maintenance host will lead to eradication of the virus cycle in the ecological community.
- *Spillover host.* Infected hosts that belong to species that do not normally maintain the virus biotype in question. These hosts are not maintenance hosts and have no epidemiological significance in sustaining rabies epidemics. Spillover hosts are often, but not always, dead-end hosts. They may transmit infection to other hosts, although such events are relatively uncommon. Spillover hosts include humans and other primates, horses, cattle, sheep, pigs and some wild species.

The virus dose required to cause infection is higher for nonmaintenance species than for the maintenance host. The probability of establishing infection is also lower, the clinical and pathological course of the disease is less consistent, and virus shedding, and therefore transmission, is less effective.

The maintenance hosts of rabies virus are usually members of the orders Carnivora and Chiroptera. Domestic dogs are a major maintenance host in much of the world, as they were in Europe and North America before the early decades of the 20th century. Dogs still cause the majority of human rabies in the world today. In some areas of the world where dog rabies has been controlled, wildlife species have become more important for maintenance of the disease. This includes the red fox and raccoon dog in Europe; striped skunks, raccoons, red and grey foxes, and coyotes in North America; side-striped and black-backed jackals, various mongoose species (particularly the yellow mongooses) and bat-eared foxes in southern Africa; and the Arctic fox in the northern polar areas. Table 1.2 gives examples of terrestrial maintenance-host species and their localities.

Other hosts include many species of American bats. The disease appeared in the Americas during the 20th century following ecological changes that allowed major increases in bat density.

Although most, if not all, warm-blooded animals are susceptible to infection with rabies virus, rabies is not regarded as a disease of avian species. In most cases where the infection has been observed in birds, it was experimentally induced (Gough and Jorgenson 1976; Scott 1993). Birds therefore do not play a significant part in the maintenance or spread of rabies virus. The susceptibility of Australian native animals is unknown.

Table 1. 2 Examples of maintenance-host species for rabies virus (genotype 1) biotypes

Maintenance host	Locality
<i>Family Canidae</i>	
Domestic dog (<i>Canis lupus</i>)	Africa, Asia, and Central and South America
Arctic fox (<i>Alopes lagopus</i>)	Arctic regions
Raccoon dog (<i>Nyctereutes procyonoides</i>)	Eastern Baltic states
Red fox (<i>Vulpes vulpes</i>)	Europe, ^a Canada (Ontario), USA (northeast)
Bat-eared fox (<i>Otocyon megalotis</i>)	South Africa (Cape)
Black-backed jackal (<i>Canis mesomelas</i>)	Southern Africa
Side-striped jackal (<i>Canis adustus</i>)	Zimbabwe
<i>Other Carnivora</i>	
Striped skunk (<i>Mephitis mephitis</i>)	USA, Canada
Raccoon (<i>Procyon lotor</i>)	USA, Canada
Indian mongoose (<i>Herpestes auropunctatus</i>)	Caribbean
Yellow mongoose (<i>Cynictis penicillata</i>)	South Africa

USA = United States of America

^a Rabies has been eradicated in western Europe.

1.3 World distribution and occurrence in Australia

Rabies virus occurs throughout most of the world except in Australia, New Zealand, Papua New Guinea, Japan, Great Britain and Ireland, and many small island nations. In some areas of the world (eg parts of western Europe), effective management of rabies in animals has reduced the frequency of occurrence of rabies in humans, and led to its eradication. However, the number and size of rabies-free countries, territories or areas is small compared with those of rabies-affected areas. Recently, there has been an outbreak of rabies in Indonesian islands such as Bali and Flores; previously, these islands had been considered rabies free.

Human rabies is found wherever animal rabies is found. Globally, human deaths from rabies are estimated to be between 55 000 and 100 000 per year. About 95% of these deaths occur in Asia and Africa. World Health Organization (WHO) data on human and animal rabies are available from the WHO website.⁶ The most up-to-date information on the global rabies situation is given in the World Animal Health Information Database (WAHID) Interface.⁷

In Australia, there was one probable occurrence of transmission of rabies. This occurred in Tasmania in 1867 and involved several dogs, a pig and a child bitten by one of the dogs. In two more recent cases (1987 and 1990), individual children who contracted the infection in endemic countries developed the clinical disease in Australia after a protracted incubation.

⁶ <http://apps.who.int/globalatlas/default.asp>

⁷ www.oie.int/wahid-prod/public.php?page=disease_outbreak_map

1.4 Diagnostic criteria

1.4.1 Clinical signs

Animals

It is important to recognise the variability of the clinical syndrome. The clinical signs of rabies can, in many instances, be subtle and even unremarkable.

Clinical signs of the disease are attributable to the neurological effects of the infection. Clinical signs may change as the disease progresses and may be intermittent, alternating between different states during the course of the disease. They fall into six main categories:

- *Excitation.* This includes unprovoked aggression, overreaction to external or perceived stimuli, aimless wandering, restlessness, self-inflicted trauma (eg scratching, biting).
- *Paralysis.* This can affect any of the motor systems, causing ataxia; knuckling of distal limbs; paresis; the inability to swallow, close the jaws and lips, or retract the tongue; and facial asymmetry, including drooping ears and eyelids.
- *Loss of normal social and behavioural responses.* Wild animals will often lose their natural fear of humans. These animals may wander into urban areas and into buildings, and can be attacked and killed by dogs. Frequently, this happens at unusual times; for example, nocturnal animals may appear during the day. In companion animals, owners may report a 'personality change'.
- *Unusual vocalisation.* Many rabid animals will vocalise relentlessly. In dogs, the tone is altered, due to muscular incoordination of the larynx, causing a characteristic low-pitched, hoarse howling.
- *Pica.* Rabid animals, particularly carnivores, will chew, and often swallow, anything in their environment, including soil, plant material and bedding.
- *Coma.* This is seen in the terminal stage of the disease.

A rabid animal's signs can often rapidly change; for example, a dog may change, without provocation, from resting quietly to running frenziedly. Cats may attack suddenly and without warning. In addition to the above, animals may suffer from signs secondary to the direct neurological changes, including dehydration, red eyes, salivation, poor condition, unkempt pelage and signs of trauma. However, cases have been reported where death has occurred with few, if any, premonitory signs.

In much of the traditional literature, the clinical signs of rabies are classified into furious and dumb syndromes. While this may have been a useful classification, particularly for dog rabies, the clinician must take care not to let this bias prevent them from noticing other manifestations of the disease.

Dogs

There is a prodromal stage, which lasts 2–3 days, but is often missed by the dog's owner. During this stage, there is a sudden change in temperament. Dogs that are normally friendly towards people may suddenly become snappy and uncertain, and shy dogs may become affectionate. There may be a rise in temperature, dilation of the pupils and hyperaesthesia at the wound site.

A rabid dog will typically become unusually restless, seldom lying or sitting in one place for more than a short time. If confined, it will move around ceaselessly. At certain periods, the dog may seem possessed of abnormal strength and insensitivity to pain. Bars of cages, furniture and other objects are frequently attacked to the point where the animal's teeth are reduced to stumps and the mouth lacerated. If the dog is not under restraint, this excitable energy is manifested by furious, aimless running (sometimes for long distances), and by snapping at animate or inanimate objects in its path. Alternatively, the dog may remain quiet and lethargic; it may hide behind cover and bite only when provoked.

In many cases of rabies, the animal's pupils are dilated, there is loss of the corneal reflex, and there is sometimes a squint. The animal assumes a watchful, puzzled or apprehensive look, and may snap at imaginary objects. There is a change in phonation, often with a characteristic low-pitched, hoarse howling. Their appetite for usual foods decreases, and animals start to eat stones, sticks, earth and other objects. There may be muscle tremors and paralysis of the hindquarters, the jaw ('dropped jaw') and the tongue, which hangs flaccidly from the mouth. There may be drooling from the mouth. Often, the rabid dog is unable to eat or to lap water, although it may repeatedly try to do so. In contrast to human rabies, hydrophobia is a rare sign in dogs and other animals. Within 1–4 days of the onset of symptoms, there is rapidly progressing ataxia. Death supervenes within a few days, usually from paralysis of respiratory muscles.

Cats

The clinical signs in cats are generally similar to those in dogs, but unprovoked aggression is a more common presenting sign. Rabid cats often retreat into hiding, from where they spring to attack humans or other animals ferociously when approached. Their pupils are dilated. They may mew continuously and the vocalisation becomes hoarse. As the disease progresses into the paralytic phase, the animal shows marked incoordination, followed by posterior paralysis. The muscles of the head become paralysed, and the animal soon lapses into a coma and dies.

Horses

Clinical signs of rabies in horses are highly variable and can be easily confused with other diseases affecting the nervous system, such as cervical vertebral malformation or other viral encephalitides.

Periods of marked excitation and aggressiveness alternate with periods of relative calm. In periods of excitation, affected animals become restless, stare, paw, move their ears, draw their upper lips back and forth continually, and salivate excessively. There may be intense sexual excitement. Animals frequently grind their teeth, whinny as if in great pain, and show signs of acute colic, which may present as oesophageal obstruction. They may lash out with great fury at any perceived threat or restraint (donkeys will often attack and bite other animals and people). They often bite or rub at the site of exposure, causing self-mutilation. As

paralysis develops, they fall repeatedly, finally remaining down with their legs thrashing. In some cases, the excitatory phase is absent and there is dysphagia, aimless wandering or staggering, and a rapidly developing paralysis. Equine rabies progresses rapidly, with most affected animals becoming depressed, recumbent and comatose before dying within 5 days of the onset of clinical signs.

Cattle

In cattle, there is initial depression and cessation of milk production. Paralysis of throat muscles with grinding of teeth and excess salivation is common, and may lead to a false diagnosis of oesophageal obstruction. Cattle may bellow frequently in a low-pitched voice. There is increased sexual excitement. Some animals develop one or more furious stages, and may attack other animals or objects; they charge and butt, but seldom bite. Other animals show little excitement.

As paralysis develops, cattle knuckle over at the fetlocks, stumble and fall frequently. Finally, they are unable to rise, lapse into a coma and die.

Sheep

In sheep, a period of excitement occurs, during which affected sheep move restlessly, salivate and grind their teeth. They also show twitching of the lips and oscillation of the tongue, pulling of wool and aggressive butting of other sheep or objects. Rams exhibit sexual excitement. Sheep may either be silent or emit frequent hoarse bleats. The excitation stage is followed by depression, increasing weakness, paralysis and recumbency. Sheep generally die within 72 hours of the onset of clinical signs.

Pigs

Affected pigs tend to stand trembling in a darkened corner, but may dash out and bite if provoked. They may rub or gnaw at the bite site. There is abnormal deep grunting. Depraved appetite is common. There may be alternating periods of intense activity and recumbency. Sows may kill their offspring. There is increasing dullness, incoordination and paralysis.

Foxes

In foxes, the normal fear of people and other animals is lost. The normal social etiquette between foxes, particularly with regard to territoriality, is not observed by the rabid fox, leading to conflict. Anorexia, agitation and a characteristic abnormal cry occur. A rabid fox may charge at and bite passing people, animals and even vehicles. As the disease progresses, the fox becomes more confused and uncoordinated. With the onset of paralysis, it falls and may be unable to rise. It may attempt to drag itself before finally lapsing into a coma and dying.

Other wildlife species

In other wildlife species, the clinical signs are variable. The most important common feature is loss of normal shyness and fear of people and other animals. This makes such animals particularly dangerous to children, who wrongly interpret this behaviour as indicating friendliness.

Humans

The clinical manifestations of rabies in humans are well described (Heymann 2008), and the disease is almost invariably fatal.

1.4.2 Pathology

Gross lesions

Usually, no remarkable gross pathological signs are evident; when present, they are secondary to the neurological effects. Carcasses are often dehydrated and in poor physical condition, and may have physical signs of recent trauma; for example, broken teeth. In carnivores, signs of pica, such as soil and plant material in the mouth and stomach, may be present.

Microscopic lesions (histopathology)

Microscopically, the most significant lesions are in the central nervous system, and cranial and spinal ganglia. There is usually perivascular cuffing, focal and diffuse gliosis, neuronal degeneration, and intracytoplasmic inclusion bodies (or Negri bodies) in the neurones. Negri bodies vary in size with the host – they are large in dogs and cattle. Negri bodies are found most commonly in the neurones of the hippocampus or in the Purkinje cells of the cerebellum in cattle. They are found less frequently in the glial cells, in ganglion cells of the salivary glands and adrenal medulla, and in the retina.

Pathogenesis

Rabies virus is transmitted through saliva by the bite of a rabid animal. After the inoculation of virus into a wound, virus replicates in local tissues. Within hours to days after a bite, there is invasion of peripheral nerve endings, followed by centripetal movement of virions along axons to the central nervous system (CNS). Once the CNS is invaded by virus, clinical signs become apparent and the disease course is irreversible. CNS infection patterns and therefore clinical signs vary, but often include behavioural changes that lead to biting other animals. From the CNS, virus invades peripheral nerves, leading to virus infection of many peripheral tissues, including salivary glands. Virus infection of salivary acinar cells leads to shedding of large numbers of virions into saliva. Shedding is coincident with the behavioural changes that lead to biting of other animals.

No signs – clinical, pathological or immunological – are apparent before CNS invasion, a period referred to as the incubation period. The disease, once it appears, is acute and progressive, leading almost invariably to death of the host if the animal is not destroyed beforehand. The overwhelming neural infection is unusual in that it is slow to provoke an inflammatory response. Once the inflammatory response appears, it contributes to irreversible neurological damage. This pattern of viral invasion followed by inflammatory response causes the typical progression of excitatory to paralytic disease.

A significant proportion of bites by rabid animals do not result in transmission and development of disease. This is usually due to a low dose of virus in the bite inoculum, which does not lead to detectable seroconversion. Alternatively, infection may be initiated at the site of inoculation, but is cleared before establishment in the CNS. This is known as 'abortive infection' and does not result in clinical signs of disease, but may result in seroconversion.

Although there are some reports of dogs surviving rabies or developing chronic infection in western Africa, Ethiopia and India (Veeraraghavan et al 1971, Fekadu

1972, Aghomo et al 1989, Fekadu 1991), these findings have not be reproduced in recent years. It is generally accepted that there is no carrier or latent state for rabies.

1.4.3 Laboratory tests

Rabies may be suspected in animals that display neurological signs, including behavioural changes and paralysis, followed by death within 10 days. The diagnosis must be confirmed by laboratory tests. A positive result in any species must be notified immediately to the chief veterinary officer (CVO) of the state or territory concerned, who will immediately notify their public health department equivalent.

Specimens should initially be sent to the state or territory veterinary laboratory (or other appropriate laboratory), from where they may be forwarded to the CSIRO Australian Animal Health Laboratory (CSIRO-AAHL) for testing or confirmation of positive or suspicious test results.

Specific laboratory diagnostic tests are necessary to confirm rabies infection as neither clinical signs, nor gross or histological pathology are pathognomonic. The tests currently available for rabies diagnosis are discussed in the section 'Laboratory diagnosis', below.

Further information on testing is available on the website of the Australian Government Department of Health and Ageing (www.health.gov.au).

Specimens required

Because rabies is almost invariably fatal without vaccination, operators should take adequate precautions to prevent accidental exposure or self-inoculation when collecting specimens. If a potential exposure to rabies occurs, first-aid procedures should be undertaken immediately. Medical advice should always be sought without delay, irrespective of vaccination status, as postexposure prophylaxis may be needed. Please also refer to Section 3.2 for more information on occupational health and safety aspects.

Before shipping specimens, submitters should contact the receiving laboratory to discuss arrangements for sampling, transport and sample reception.

For all species, whole animals, severed heads or unpreserved brains should be chilled and forwarded on ice to the testing laboratory. The brain is the most important specimen for laboratory confirmation of rabies. Distribution of virus in the brain is usually diffuse, but may be localised in some cases. Of the structures of the brain, the brain stem is the most consistently reliable area for detection of infectious virus or viral antigen. Other regions of the brain, including the hippocampus, are negative in up to 5% of rabid animals. For this reason, it is important to take a composite brain sample to include several different parts of the brain in the diagnostic test. If the brain is not present, other suitable tissues include spinal cord, the trigeminal ganglion, peripheral nerves (taken from points close to the CNS) and salivary glands.

Unless the operator is vaccinated and experienced, the head or brain should not be removed before submission because of the risk of self-inoculation.

Tissues should be kept cold for storage and transport to the laboratory. They should not be placed in formalin, as this precludes their use or reduces their reliability for all the principal diagnostic tests. However, unpreserved and formalin-fixed samples of other tissues should be collected at necropsy to aid differential diagnosis.

Freezing of specimens should be avoided unless chilling is not possible. However, freezing should be considered if long-term storage is necessary. Freezing does not affect the major diagnostic tests, but thawing of large specimens may increase the time to obtain results. Decomposition may affect the reliability of diagnosis, particularly culture methods. However, provided tissue material is present, the state of decomposition should not influence the decision to test, as antigens and viral RNA can successfully be detected in even the most severely decomposed tissues.

It is important that all the appropriate epidemiological information – including precise and accurate identification of species and geographical origin – is acquired and included on the laboratory test request form. If necessary, a taxonomist should be consulted for the correct identification of wildlife.

Transport of specimens

For cost-effectiveness and ease of shipping, it may be necessary to consider removing the head or brain of larger animals in the field, or at a regional veterinary facility, rather than at the diagnostic laboratory. Many diagnostic laboratories do not have the facilities to deal adequately with large carcasses. However, the risk of self-inoculation should be carefully managed. It is preferable that the procedure is undertaken by vaccinated and experienced operators.

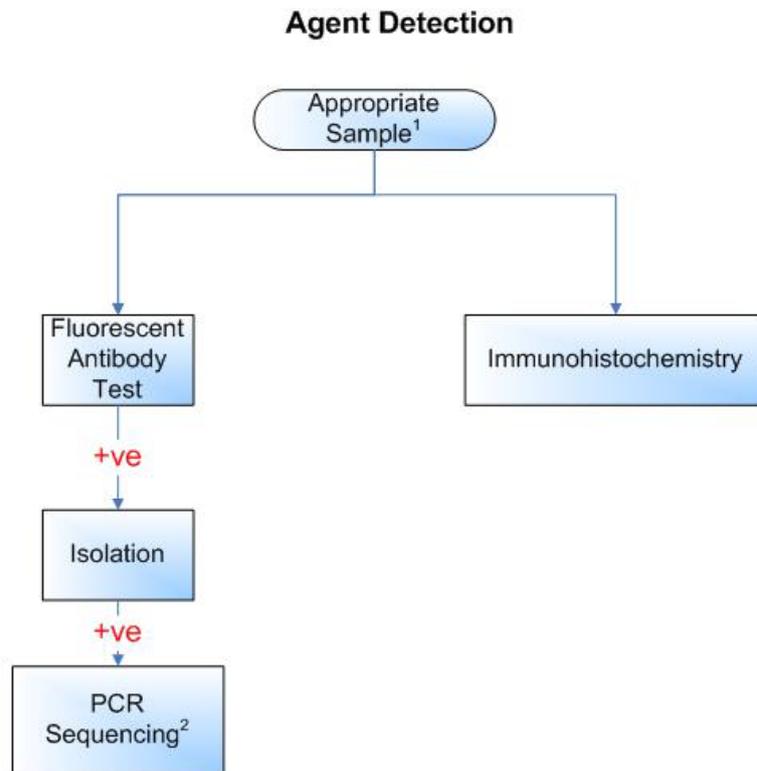
Firstly, the necessary clearance from the CVO of the state or territory of the disease outbreak should be obtained, and the CVO of Victoria should be informed about the transport of the specimens to Geelong. Then specimens should be sent to the state or territory diagnostic laboratory, from where they will be forwarded to AAHL, Geelong, for emergency disease testing.

Laboratory diagnosis

The testing method used by CSIRO-AAHL is shown in Figure 1.1. Further details of tests currently available at AAHL are shown in Table 1.3.

The fluorescent antibody test (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 of the tests used. It involves applying a specific fluorescein-labelled antibody – directed against the viral nucleocapsid protein – to a smear of brain tissue. Current FAT reagents react to all lyssaviruses and are not rabies specific. Differentiation of rabies from other lyssaviruses requires characterisation of the viral genome by molecular genetic techniques (eg polymerase chain reaction [PCR] and sequencing).

AAHL Rabies Testing Algorithm



1. Brain, salivary gland, CSF, saliva. Fixed brain or salivary gland for IHC.
2. Selected isolates

Figure 1.1 The current approach to diagnostic testing for rabies used at CSIRO-AAHL

Table 1.3 Tests currently available at the CSIRO-AAHL for use in the diagnosis and control of rabies

Test	Specimen	Test detects	Time taken to obtain result
<i>Agent detection</i>			
FAT	Fresh brain	Viral antigen	1 day
Immunohistochemistry	Formalin-fixed brain	Viral antigen	2 days
<i>Agent characterisation</i>			
Virus isolation in neuroblastoma cell cultures	Fresh brain	Live virus	5 days
PCR and sequencing	Fresh brain, cultured virus	Viral genome	3–4 days
Virus isolation in mice	Fresh brain	Live virus	28 days
<i>Serology</i>			
ELISA	Serum	Antibodies	1 day
RFFIT (serum neutralisation test)	Serum	Antibodies	3 days
FAVN (serum neutralisation test)	Serum	Antibodies	3 days

ELISA = enzyme-linked immunosorbent assay; FAT = fluorescent antibody test; FAVN = fluorescent antibody virus neutralisation; RFFIT = rapid fluorescent focus inhibition test; PCR = polymerase chain reaction

Source: CSIRO-AAHL, 2010 (refer to CSIRO-AAHL for most up-to-date information)

As at October 2009, appropriate laboratories for confirming results are:

- CSIRO-AAHL⁸ (see Table 1.3 for current diagnostic tests);
- Queensland Health Forensic and Scientific Services (QHFSS);⁹ and
- Queensland Primary Industries and Fisheries Biosecurity Sciences Laboratory (BSL).¹⁰

Although other state and public health laboratories may offer some diagnostic tests, the confirmation of diagnostic results must be by one of the laboratories listed above.

Laboratory procedures for the diagnosis of rabies fall into three categories: antigen detection assays, nucleic acid detection assays and culture for live virus. Before the development of antigen detection tests in the 1950s, histological techniques, using chemical stains such as Seller's stain, were used for the detection of the characteristic Negri bodies. However, such assays are so insensitive that they are of almost no value for the medical management of contact victims. Biopsy of the brain may also be required.

The first-line diagnostic test in most laboratories is the FAT, which can be performed and produce results within 1–2 hours.

For this test, fresh brain or other nerve tissue is used to make impression smears, which are then fixed and stained by incubating with fluorescein-labelled anti-rabies antibody, and observed under a fluorescence microscope. In experienced hands and with superior reagents, this test is highly reliable and back-up tests rarely change the outcome. These features, combined with its relative low cost and rapid test time, make the FAT a highly robust assay that would be difficult to surpass. However, the FAT cannot be performed reliably on formalin-fixed samples.

In recent years, PCR methods have become the main auxiliary tests for rabies. Real-time PCR tests using TaqMan technology are reliable and rapid, with results available on the same day. They are, however, considerably less sensitive if the samples are fixed in formalin. Subsequent sequencing of PCR products may provide important epidemiological information on the virus.

Culture methods are the oldest diagnostic tests. Cell cultures are performed using mouse neuroblastoma cells, a cell line that is highly sensitive to rabies virus. Mouse inoculation is also a reliable test, although now rarely used as a routine detection test. Apart from their value as diagnostic tests, culture methods are appropriate where virus needs to be amplified for detailed antigenic and genetic characterisation. Their main disadvantage as diagnostic assays is their long performance times – up to 5 days for cell cultures and up to 3–4 weeks to confirm a negative result in mice. Culture for rabies virus also has the disadvantage that it

⁸ CSIRO Australian Animal Health Laboratory, 5 Portarlington Road, Geelong, Victoria 3219 (contact the duty veterinarian)

⁹ Biosecurity Services Laboratory (contact the duty veterinarian). This laboratory is colocated with QHFSS at 39 Kessels Road, Coopers Plains, Queensland, 4108.

¹⁰ Health and Food Sciences Precinct, specimen receipt (loading block 12), 39 Kessels Road, Coopers Plains, Queensland, 4108

cannot be performed on formalin-fixed tissues. Culture methods are also less sensitive than the FAT and PCR tests when specimens are decomposed.

Immunohistochemistry is an antigen-detection assay that is performed on sections of tissue. If appropriately selected anti-rabies antibodies are used, this test can be highly sensitive and specific on formalin-fixed tissues. A minimum of 2 days are needed to return a test result.

Most high-proficiency laboratories will attempt to use more than one test to reach a final diagnosis, particularly where human contact is involved. The reliability of a diagnostic test is dependent on several factors. Given optimal equipment and operator performance, the two primary areas that affect test performance are specimen quality, and the quality and design of the reagent probe (antibody or primer). The most common reasons for test failure are examination of a single, rather than a composite, brain sample; diagnostic antibody or primer mismatch, particularly with unusual lyssavirus types; and severe decomposition of the specimen.

Virus typing is important to characterise the probable origins of virus strains. Once the sample has been diagnosed as positive, the virus can be typed by PCR amplification and gene sequencing, or by antigenic reactivity to panels of monoclonal antibodies.

Serology tests are of no value for the diagnosis of rabies, although they have supported diagnosis in several human cases that have exhibited symptoms but have survived the infection. These patients showed high levels of antibodies with no detectable antigen at presentation. Serology tests are useful for confirming vaccine responses in animals and humans. Virus neutralisation tests (rapid fluorescent focus inhibition test [RFFIT] or fluorescent antibody virus neutralisation [FAVN]) have been developed for this purpose. As these tests are performed on cell cultures, the serum samples should be taken carefully and separated from the cellular components of the blood as soon as possible to minimise the toxic effects of cell lysis.

Further characterisation

The virus isolate in an outbreak will be further characterised by gene sequencing. This not only differentiates rabies virus from other lyssaviruses, but can also provide valuable epidemiological information on the possible origin of the virus and its likely maintenance host(s) (ie the biotype), which is of central importance in developing the response strategy.

Weak or negative fluorescent antibody staining may be obtained from brain specimens of human or animal patients that have had clinical signs indicative of rabies. If neurological signs and death occur in mice inoculated with such brain specimens, a divergent lyssavirus should be suspected as the aetiological agent.

Case definition

For the purposes of an emergency disease response, a case of rabies is one that is confirmed by any of the tests listed in Table 1.3 and gene sequence analysis indicating that the agent belongs to a lyssavirus genotype 1 lineage that is known to be a terrestrial mammal or bat biotype (see Table 1.1).

1.4.4 Differential diagnosis

Any other causes of neurological dysfunction should be considered as differential diagnoses for rabies. Change in behaviour is the key clinical sign for wildlife and domesticated animals, and this sign may be missed by the owner or handlers of an affected animal. The disease in all mammals is acute, progressive and fatal. Where this is not the case, rabies can usually be excluded.

The following conditions must be considered in the differential diagnosis:

- viral encephalitides
 - canine distemper and infectious canine hepatitis
 - Aujeszky's disease
 - Borna disease
 - eastern, western and Venezuelan equine encephalomyelitis viruses
 - West Nile virus, Japanese encephalitis virus and other flaviviruses
 - various insect-borne reoviruses
 - Australian bat lyssavirus;¹¹
- bacterial and mycotic diseases of the CNS, including listeriosis and cryptococcosis;
- poisonings, including by '1080' (sodium fluoroacetate), heavy metals (eg lead), chlorinated hydrocarbon and organophosphate pesticides, urea, 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
- bovine spongiform encephalopathy.

1.4.5 Treatment of infected animals

The treatment of infected animals is ineffective.

1.5 Resistance and immunity

1.5.1 Innate and passive immunity

There is no evidence of naturally occurring innate immunity to rabies virus. Transient passive immunity occurs in offspring of vaccinated animals.

¹¹ www.animalhealthaustralia.com.au/aahc/index.cfm?3C0BD05B-9FCB-F40F-5367-0F5F6F2ED92C

1.5.2 Active immunity

Active immunity can be induced by vaccination. In humans and some animals, this can be used to prevent clinical disease. Active immunity is ineffective in resolving clinical disease, and there is no carrier state.

Antibody has been detected in clinically normal, nonimmunised animals and is thought to be associated with transient infection without the development of clinical disease. There is no evidence that these animals pose a risk of transmission.

1.5.3 Vaccination

Parenteral vaccination programs are widely implemented overseas for rabies control. Oral administration of vaccine is generally used in the control or reduction of wildlife rabies. Modified oral live virus vaccines and live recombinant vaccines have been very effective in inducing adequate immunity in many species, including foxes, and for significantly reducing the incidence of rabies in wildlife. All vaccines currently used for oral vaccination programs are either modified live virus vaccines or live recombinant vaccines.

Domestic animals

Nobivac Rabies (Intervet) is the only registered parenteral rabies vaccine in Australia. Currently, it can only be used for vaccinating animals for export, so in the event of a rabies outbreak, the vaccine would have to be approved for domestic use. This would be done through the Australian Pesticides and Veterinary Medicines Authority (APVMA) and the Australian Government Department of Agriculture, Fisheries and Forestry.

The Nobivac Rabies vaccine is inactivated, and has been assessed as being safe and efficacious. It is therefore unlikely to induce disease in the recipient animal.

Some animals in Australia may have been vaccinated overseas before importation. Maternal antibodies persist until 10–12 weeks of age (Precausta et al 1982); therefore, offspring from vaccinated dams must be at least 3 months old before receiving their first vaccination. Vaccinations and boosters should be delivered in accordance with the manufacturer's recommendations. Revaccination will be considered in the face of an outbreak regardless of an animal's rabies vaccination history.

WHO recommends that, for mass canine vaccination campaigns, at least 80% of target populations need to be vaccinated to control rabies (WHO 2007).

Post-vaccination serology

The OIE accepts a minimal rabies serum neutralising antibody titre of 0.5 international units (IU)/mL as an indication that the animal has responded to vaccination. Following vaccination of dogs and cats, serological testing is important to determine if adequate seroconversion has occurred. Measurement of virus-neutralising antibodies is used to indirectly assess vaccine efficacy.

Where exposure of a domestic animal to a rabid animal is unlikely but unknown, postexposure treatment may be considered by the Consultative Committee on Emergency Animal Diseases (CCEAD) on a case-by-case basis.

Further detailed information on immunisation of domestic animals can be found in the *Compendium of Animal Rabies Prevention and Control* (National Association of State Public Health Veterinarians 2008).

Vaccination of livestock is not essential for eradication, but may be desirable to prevent sporadic cases in these animals and the subsequent risk to humans. Pleasure horses, valuable stud animals and any other animal that comes into frequent human contact during the incursion should be considered for vaccination.

Humans

Safe and efficacious vaccines are available for human use, both for pre- and post-exposure prophylaxis. Information can be found in the *Australian Immunisation Handbook*, 9th edition (NHMRC 2008). Section 3.2.2 has further information on who should be vaccinated and when.

Wildlife

Vaccination

Overseas, oral vaccination is an important tool to control the spread of rabies in wildlife populations – ongoing programs are implemented annually, particularly in Europe and North America (Blanton et al 2007). Programs involve distributing baits containing orally immunogenic vaccines throughout the landscape, targeting wildlife. The programs aim to establish population immunity, and thus prevent spread of rabies or eliminate species-specific variants (Sterner et al 2009). Oral vaccines are also effective in immunising domestic dogs under experimental conditions, and experimental trials have demonstrated their potential in field situations.

Oral vaccination is made possible by the ability of vaccine strains to elicit an immune response through the oral/pharyngeal route by local infection of mucous membranes (Wandeler 1991). For this reason, oral rabies vaccines consist of live viruses. Inactivated antigens are not effective.

Oral vaccination in foxes was used to control rabies in western Europe in the 1970s. As a result, the prevalence of fox rabies rapidly decreased, and France and Switzerland were declared free from rabies in terrestrial animals by 2000, although bats in these countries still carry lyssaviruses. The oral rabies vaccination programs in Europe mainly used attenuated rabies virus vaccines, which were highly effective in immunising fox populations. However, they caused a small number of vaccine-induced rabies cases and were not very effective in other species (Blanton et al 2007). During the 1980s, a vaccinia-rabies glycoprotein (V-RG) recombinant virus vaccine was developed. V-RG was extensively used in the United States of America to control rabies in various maintenance hosts (Blanton et al 2007). However, the efficacy of V-RG vaccine in some species, including skunks, is limited (Blanton et al 2007). Although safety in animals is generally good, vaccinia recombinant vaccines have occasionally caused local and disseminated vaccinia infections in humans, and for this reason recombinant vaccines using other, less pathogenic viruses are being developed.

The Ministry of Natural Resources in Ontario, Canada, has managed a rabies control program that has been very successful in eliminating fox rabies from many areas with the use of vaccine baits.¹²

Vaccination will markedly reduce the frequency of rabies in maintenance and spillover hosts. In maintenance hosts, immunisation coverage of more than 50% of the population will result in a significant decline. Immunisation coverage of more than 70% should lead to the eventual eradication of the disease. For dogs, a total population vaccination level of 80% is desirable (WHO 2007). Injectable vaccines have played a major role in eradicating dog biotypes in Europe, North America and Japan, and reducing their frequency in many other regions. Oral vaccines, placed into baits, have reduced or eradicated wildlife rabies over large areas of Europe and North America.

Although rabies vaccination campaigns using oral vaccines have been successful in European and North American wildlife populations, oral vaccination of domestic dog populations has not progressed beyond field experimental stages. Dog rabies is predominantly a problem of resource-poor countries. Although oral vaccination may allow the effective immunisation of a proportion of dogs that cannot easily be caught, these campaigns require significant resources. In addition, the use of live vaccines in companion animals is not well supported. This is due to the small risk of the pet acquiring vaccination-induced rabies, which could potentially be transmitted to humans – an impediment to its ready adoption.

Detailed guidelines for oral vaccination programs are available at the WHO website (WHO 2007).

Overseas protocols for oral vaccination of foxes would be expected to be applicable in the Australian situation. Experimental field protocols that have demonstrated the potential for oral vaccination of dogs may be applicable in some circumstances in Australia. However, the safety and efficacy of bait administration in native Australian species has not been assessed, and WHO recommends that a risk assessment be undertaken before the release of vaccine bait into the environment.

Trap-vaccinate-release

Trap-vaccinate-release (TVR) involves capturing live wildlife with cage traps and vaccinating by intramuscular injection. It has been used for rabies management in urban skunks and raccoons in North America. This method could be used to conserve endangered species. It could also be used to manage rabies in wildlife that live in areas inhabited by people where population-reduction methods and oral-baiting methods are unsuitable or unacceptable to the public, or where satisfactory baits have not been developed. TVR may be preferable to depopulation in some species, as the latter causes a population sink into which infected or susceptible animals migrate (see 'Population reduction', below).

¹² www.mnr.gov.on.ca/en/Business/Rabies

Population reduction

Widespread, sustained population reduction of animal reservoirs (eg by shooting, gassing, poisoning) to eliminate rabies is not justified for epidemiological, ecologic, economic and ethical reasons (Rupprecht et al 1995).

Maintenance hosts of rabies have high potential rates of population replacement. Even in the face of heavily sustained population removal, they are able to replace population losses at a sufficient rate to maintain rabies virus cycles. Paradoxically, unless it is very heavy, host depopulation can be counterproductive. By removing mature, socially stable animals, depopulation leads to dispersal and a younger demographic structure. This results in higher host-contact rates and greater potential to spread disease.

Nevertheless, some degree of population management is necessary, particularly with companion animal species. Stray and nuisance dogs and cats should be impounded and, if necessary, destroyed. Such policy is important at all times, but particularly during a rabies epidemic.

1.6 Epidemiology

In dogs and other maintenance hosts, outbreaks of rabies occur in local, explosive epidemics of particular biotypes that last for several months. After the main epidemic in a particular area (involving a discrete group of animals) has passed, the outbreak will tail off before becoming locally extinct. However, it may take several years before extinction and occasional cases of disease may still occur during this time. The population then becomes susceptible to reinfection. If sufficiently isolated, local host populations may remain free from rabies for long periods before the next epidemic is initiated.

Maintenance hosts are able to establish dense populations and have high potential-replacement rates. In intense epidemics, the disease itself becomes the major factor controlling host population size. A significant proportion of the maintenance host population is affected and the population density falls, often catastrophically. The transmission ratio falls below the threshold of sustainability and the disease dies down, allowing the host density to recover to its pre-epidemic level. Variation in the relationships and contact between different local populations will increase the chance that there is always at least one infected local population to sustain the disease over the long term.

In cattle, sheep and other herbivores, spillover cases of rabies coincide with rabies in a maintenance host. There are often several nearly simultaneous cases in cattle and sheep herds, resulting from multiple attacks by a rabid animal. However, it is possible that limited transmission between animals in a herd may occur through grooming and drinking from the same water trough. Cattle appear to be highly sensitive to rabies, as its incidence is high in cattle where the disease is present in a maintenance host. This may be due partially to their innate curiosity, which would draw them towards rabid animals.

Ecological factors are critical in determining the epidemiology in the different host species. Dog biotypes are dominant in human societies, both urban and rural, that do not place restricted movement on the dog population. Conversely, in societies that confine dogs to yards and homes, dog rabies is likely to be reduced. The most effective wildlife maintenance hosts establish dense populations, have high

potential replacement rates, and have adapted well to urbanisation and habitat pressure.

1.6.1 Incubation period

The incubation period in animals, including humans, is highly variable. It is generally 3–8 weeks, but can vary from 2 days to 6 months or even longer – up to 6.5 years in humans (Bek et al 1992). Incubation periods in excess of one year have been documented in animals, but rarely so. The OIE *Terrestrial Animal Health Code* gives a maximum incubation period, for regulatory purposes, of 6 months.

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

1.6.2 Persistence of agent

General properties and the environment

Rhabdoviruses are bullet-shaped and contain single-stranded, unsegmented RNA, which is complementary to messenger RNA and is enclosed in a nucleocapsid protein complex. Rabies viruses are relatively large and contain lipids; hence they are susceptible to a wide range of disinfectants, including warm soapy water, iodine preparations and detergents (see Section 3.2.3, 'First aid').

Rabies virus is comparatively fragile and does not survive for long periods outside the host. The virus is inactivated by heat, and is susceptible to ultraviolet (UV) light, lipid solvents (soapy water, ether, chloroform, acetone), 45–75% ethanol, quaternary ammonium compounds (eg 0.2% cetrimide) and 5–7% iodine preparations. However, the rate of inactivation of rabies virus by physical and chemical conditions is greatly modified by the stabilising effects of polypeptides and other compounds (Kaplan et al 1966, Michalski et al 1976, Matouch et al 1987, Scott Williams Consulting Pty Ltd 2003).

Some authors have suggested that refrigerated virus or virus preparation at pH 5–10 may remain stable for extended periods. Others have thought that the virus may be inactivated by direct sunlight and UV light, and that the virus is labile to proteolytic enzymes, but no supporting data are provided (Fernandes et al 1963, Swanepoel 1994). Survival of rabies virus in the saliva of dead carcasses is unknown, but continued infectivity for a period postmortem cannot be dismissed, particularly in temperate conditions.

Although aerosol contamination in bat caves is well recognised, there are no studies proving that other routes of environmental contamination play any significant role in transmission of rabies (Gibbons 2002).

Live animals

The virus is shed in saliva from about the time of onset of clinical signs. Virus shedding 1–5 days and up to 13 days before clinical signs appear has been reported. Rabies virus has not been identified in other bodily secretions more than 2 weeks before confirmed infection (Fekadu 1988, Greene and Rupprecht 2006).

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

1.6.3 Modes of transmission

Live animals

Rabies virus is transmitted by contamination of a fresh wound with virus laden saliva. This is usually from the bite of a rabid animal, but can also result from licking abraded skin or mucous membranes. The virus cannot penetrate intact skin.

Respiratory and oral transmission can also occur, but is considered uncommon. In exceptional circumstances, transmission from mother to suckling young has been reported. For practical purposes, these routes can be ignored in framing control strategies.

Transmission risk in laboratory situations includes splashing onto mucous membranes and aerosol exposure (Gibbons 2002).

Animal carcasses

There is neural spread of virus from the brain to various organs and tissues during the clinical phase of the disease. Therefore, the entire carcass is regarded as potentially contaminated with rabies virus.

Animal products and byproducts

Any products or byproducts from a rabid animal should be regarded as potentially infectious and not permitted into the food chain.

Equipment and personnel

Equipment and personnel are not recognised as significant in the transmission of rabies virus.

Vectors

Transmission of rabies virus by arthropod vectors is not known to occur.

Semen and embryos

No evidence exists for transmission in semen or embryos.

Other modes of transmission

Transmission of rabies by the transplant of the cornea and other organs has occurred in humans (Gibbons 2002).

In several species of mammals, including dogs, cattle, bats and laboratory rodents, rabies has been reported to have been transmitted across the placenta from mother to fetus. This is considered an infrequent mode of transmission.

In two separate incidents, aerosols created during laboratory procedures infected two staff members. One person had been using a blender to homogenise rabid goat brains (Winkler et al 1973), and the other had been spraying live rabies virus in a pharmaceutical manufacturing machine (Tillotson et al 1977).

1.6.4 Factors influencing transmission

The population density of susceptible (ie nonimmunised) maintenance-host species is important for transmission. Epidemics often spread on a slow-moving front; for example, 30–60 km per year in fox rabies in Europe (Toma and Andral 1977). However, this is influenced by migration and seasonal dispersal patterns of the host species. Dog rabies can be rapidly spread to new areas by dogs with furious rabies that have running fits (where they may travel distances of more than 30 km) or by pets moved to new areas by their owners.

Australia has widespread and abundant populations of wildlife and feral animals that are known to be maintenance hosts of rabies in other countries. Carnivore species in Australia that may be potential hosts are the European red fox, the feral cat, the feral dog and the dingo. It is difficult to predict with certainty which wildlife species would be involved in an outbreak in Australia. Although threshold densities needed to maintain rabies vary widely, even within the same species (eg the red fox in Canada and Europe), it is known that Australia has densities of the European red fox that greatly exceed the densities of rabies-infected populations within endemic countries.

1.7 Manner and risk of introduction to Australia

The highest risk for a rabies virus dog biotype to enter Australia is by the illegal entry of an infected animal (eg through smuggling or itinerant yachts). The possibility of a fox biotype entering Australia via a smuggled fox is remote. Other routes of entry – such as an infected dog with a nondog biotype being undiagnosed and entering Australia illegally or through quarantine, followed by transmission back to the maintenance host – are unlikely.

There is negligible risk that human cases of rabies will spread to animals or other people.

2 Principles of control and eradication

2.1 Critical factors assessed in formulating response strategy

2.1.1 Features of the disease

- Rabies is almost invariably fatal in both humans and animals.
- Rabies has a broad host range.
 - There are species-specific biotypes of rabies virus.
 - Hosts that are expected to maintain existing biotypes are present in Australia (eg dogs, red foxes, dingoes).
 - Rabies virus can spill over to other host species (eg humans, livestock, cats).
 - Any animal that has rabies can potentially transmit it to other animals and people.
 - Marsupial susceptibility is unknown.
- Most commonly, clinical disease will be associated with behavioural change (eg friendly dogs become aggressive, wildlife lose fear of people).
 - Clinical signs can be variable and unremarkable.
 - Clinical signs are not diagnostic; laboratory testing is required.
- In an outbreak, rapid laboratory diagnosis is needed and adequate laboratory surge capacity is necessary.
 - Definitive diagnosis requires laboratory examination of the brain, and biotype determination requires DNA sequencing. Biotype knowledge is crucial to control and management. Live animal testing does not exclude a diagnosis of rabies. Diagnosis will usually take a day from the time of receipt at the appropriate diagnostic laboratory. Early cases may go unnoticed in an outbreak.
- Rabies virus is fragile and does not persist in the environment.
- Transmission is most often by transfer of saliva, usually through biting or scratching. Parenteral or mucosal membrane exposure (eg through the eyes, oral mucosa, bites, scratches) is required.

2.1.2 Vaccination

- Vaccination is an effective technique for controlling rabies.
- Availability of vaccine for humans and animals is essential.
 - Safe and effective registered parenteral vaccines for humans and animals are available in Australia.
 - Oral vaccination programs in some species have effectively eradicated or controlled rabies in wildlife overseas.

- Overseas information suggests that more than 70% of the population needs to be vaccinated to ensure population protection in wildlife.
- The use of oral vaccine in wild animal management has been considered as an option in Australia; however, safety and efficacy would need to be evaluated, and an emergency-use permit would need to be obtained.
- The possibility of reversion to virulence of an oral vaccinal strain in Australian animals would also need to be evaluated.
- All persons involved in the operational management of rabies (eg veterinarians, field officers and their staff who may handle animals) should be vaccinated in accordance with the *Australian Immunisation Handbook*, 9th edition (NHMRC 2008). This may delay the involvement of some personnel in a response for days or weeks.
- Rabies-specific occupational health and safety issues must be considered in field operations.

2.1.3 Features of the populations

- Wildlife control expertise is available in Australia.
- Wildlife population reduction programs are not considered effective.
- There would be significant human and social impacts if rabies became established. Public outreach, communications and liaison are paramount.

2.2 Options for control and eradication

In this description of options for the control and eradication of rabies, the following terms are used:

- *Infected animal*. A live animal that develops clinical signs consistent with the disease and is known to have an epidemiological link (eg in a known infected area or area of epidemiological interest).
- *Confirmed case*. A laboratory-confirmed rabies-positive animal.
- *Susceptible animal*. Mammals are susceptible; members of Carnivora and Chiroptera are recognised as significant reservoirs. In Australia, dogs, cats, horses, cattle, sheep, pigs and foxes are important susceptible species. Wildlife and feral species may also be important.
- *Suspect animal*. An animal not known to have been exposed to a disease agent but showing clinical signs requiring differential diagnosis (ie with no epidemiological link to the disease).
- *Dangerous contact animal*. A susceptible animal that has been designated as being exposed to rabies following tracing and epidemiological investigation, and considered highly likely to be infected.
- *Trace animal*. An animal not showing clinical signs, but with an epidemiological link to the disease.

Initially, action should be directed towards preventing human exposure as far as is practicable and taking every possible precaution to reduce the risk to those involved in the handling of infected animals.

Control measures could involve any or all of the following:

- recognising rabies cases in animals as early as possible;
- defining the geographic area of the outbreak;
- seizing, and quarantining or destroying infected animals;
- tracing, seizing, and quarantining or destroying dangerous contact animals;
- controlling zoning and movement over animals, including prohibiting gatherings, sporting and recreational activities involving animals (eg an embargo on hunting dogs, and mustering that uses working dogs);
- muzzling all domestic dogs when in public to minimise the risk of transmission;
- vaccinating key populations (eg guide dogs, police dogs) early in the response;
- alerting all veterinary practices, state and territory health departments, wildlife carers, the RSPCA, animal shelters, local government animal control organisations, feral animal control organisations and other relevant stakeholder groups;
- controlling stray animals; and seizing, and detaining or destroying animals not properly controlled or vaccinated;
- vaccinating individual animals and using oral vaccinations (eg through baiting) for large populations;
- identifying vaccinated animals;
- detecting and managing the disease in wildlife;
- mounting publicity campaigns;
- reporting human exposure to possibly infected animals; and
- identifying and assessing trace animals.

Note: Population control (through culling or stamping out) has never been an effective technique in the management of rabies.

The policy to be implemented is described in Section 3.

3 Policy and rationale

For the purposes of an emergency disease response, a case of rabies is one that is confirmed by any of the tests listed in Table 1.3 and gene sequence analysis indicating that the agent belongs to a lyssavirus genotype 1 lineage that is known to be a terrestrial mammal or bat biotype (see Table 1.1).

3.1 Introduction

Summary of policy

Rabies is a notifiable disease in all states and territories of Australia, and is listed by the World Organisation for Animal Health (OIE). The detection of rabies in terrestrial (including bat) hosts in Australia would have significant public health and social impacts, particularly if the disease became widespread, or established in stray or wild animal populations. There may also be ecological and conservation concerns.

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

The default policy is to quickly eradicate rabies to prevent spread to domestic and wild animals, and humans through a combination of strategies including:

- *quarantine and movement controls* on susceptible animals in declared areas to minimise the spread of infection;
- *destruction of infected animals* to remove the most dangerous source of viruses;
- *quarantine, vaccination or destruction* of exposed animals;
- *movement control, vaccination or quarantine* of suspect animals until their rabies status has been clarified;
- *vaccination* of domesticated carnivores (eg dogs, cats, ferrets), other selected species and targeted animal groups in declared areas to protect animals against infection and reduce exposure of humans;
- *monitoring* of wild animals and, if disease establishes in those populations, consideration of implementing a vaccination program;
- *tracing and surveillance* to determine the source and extent of infection, and to provide proof of freedom from the disease;
- *linkage and coordination* of public health and environmental authorities so that they are co-responders; and
- *a public awareness campaign* to facilitate public cooperation from animal owners and the community, including other government and nongovernment authorities.

Successful implementation of the policy will depend on community cooperation and compliance with all control and eradication measures. Advice about immunisation of humans would be provided by public health authorities.

Population reduction of susceptible species is not appropriate.

The chief veterinary officer (CVO) in the state or territory in which the outbreak occurs is responsible for developing an Emergency Animal Disease (EAD) Response Plan for the particular outbreak.

The Consultative Committee on Emergency Animal Diseases (CCEAD), convened for the incident, assesses the response plan drawn up by the affected jurisdiction's CVO for technical soundness and consistency with AUSVETPLAN, and endorses or seeks modifications to it. Overall operational management of the incident rests with the CVO of the affected jurisdiction, with oversight by the CCEAD. Because rabies is a zoonosis, it is essential for human health authorities to be involved in planning and implementing the response.

The National EAD Management Group (NMG), also convened for the specific incident, decides on whether cost sharing will be invoked (following advice from the CCEAD), and manages the national policy and resourcing needs.

For further details, refer to the **Summary Document**.

CVOs of the affected states and territories will implement disease control measures as agreed in the EAD Response Plan and in accordance with relevant legislation. They will make ongoing decisions on follow-up disease-control measures in consultation with the CCEAD and the NMG, based on 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 Occupational health and safety

3.2.1 Key points

- Every person involved in a rabies eradication program who may come in contact with an infected animal should be immunised against rabies. Procedures for use of vaccine, including storage, dosage and administration, are set out in the *Australian Immunisation Handbook*, 9th edition (the Handbook) (NHMRC 2008). However, as scientific and medical knowledge of rabies and its prevention may change between revisions of the Handbook, advice should be sought from the relevant state health department on the current recommendations.
- Contact between humans and potentially infected animals should be minimised.
- Personnel who have contact with potentially infected animals should always wear appropriate personal protective equipment (PPE).

- If a potential exposure to rabies occurs, first-aid procedures should be undertaken immediately, as detailed in Section 3.2.3. Medical advice should always be sought without delay, irrespective of vaccination status, as postexposure prophylaxis may be needed.

3.2.2 Vaccination

General

Safe and effective vaccines for protecting humans against rabies are available. There are two protocols for rabies vaccination: pre-exposure vaccination and postexposure vaccination. Vaccination recommendations for staff involved in a rabies eradication program may differ from person to person, depending on the potential for exposure to live virus.

In particular, vaccination status of veterinary staff in the declared areas should be determined. Unprotected veterinary staff should be advised of risks and should be advised to seek medical advice regarding vaccination options. Unprotected veterinary staff should not handle suspect animals.

Antibody titres in vaccinated staff are likely to wane with time. It is important that an adequate titre be maintained in staff exposed to potentially rabid animals and in laboratory staff working with live virus. Regular antibody titre measurements or a vaccine booster dose may be required. The specific regimens differ depending on the nature of the potential exposure; these are outlined in the Handbook (NHMRC 2008).

Before engaging in at-risk activities, recently vaccinated people should ensure that they have a protective titre.

Postexposure vaccination

Postexposure prophylaxis (PEP) is used when a person may have been exposed to rabies virus, usually following an animal bite or scratch. PEP varies according to whether or not the person is vaccinated against rabies. For unvaccinated people, PEP includes rabies immunoglobulin. Further information is available in the Handbook (NHMRC 2008).

As rabies may have a long incubation period, medical advice about PEP should be sought regardless of the time that has elapsed since the exposure.

3.2.3 First aid and medical assessment

It is essential that, whenever a potential exposure to rabies virus occurs – via a bite, scratch, or splash onto mucous membranes or aerosol exposure in the laboratory – first aid is commenced as soon as possible to remove the virus from exposed tissue. Medical advice must be sought immediately on the appropriate course of action, irrespective of whether the person has been previously vaccinated against rabies.

Proper cleansing of any wounds, abrasions and splashes is an important first-aid measure in preventing rabies of people. If a person is bitten or scratched, or mucous membranes (eg eyes, nose, mouth or existing wounds) are splashed with any bodily fluids from the animal, the affected area should be immediately and

thoroughly washed with soap and water for approximately 15 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 (eg ethanol), may be applied to wounds after washing.

3.2.4 Handling of animals

General approach

Suspected rabid animals should be approached and handled only when necessary and only by appropriately trained personnel. Potentially rabid animals should be approached with extreme caution. If it can be done without risk to the operator, every effort should be made to capture and safely confine the animal. If the animal cannot be safely captured or confined, and therefore constitutes a risk to people or other animals, it should be immediately destroyed.

A high level of hygiene and safety measures for personnel are required in the handling of infected and suspect animals. All field and laboratory staff should be trained in the correct use of PPE and in the decontamination of reusable equipment. Contamination with aerosols and saliva is highly possible; therefore, all personnel who are associated with the program, and are handling animals and animal parts must take all necessary precautions. This includes the use of gloves, masks and eye protection.

The medical reasons for rabies pre-exposure and postexposure vaccination should be explained to all staff. They should also be fully conversant with the correct first-aid and medical procedures to be employed after a potential human exposure.

Capture and handling of animals

Nets or dog-catching poles with stout rope or wire loops may be used for small animals, and ropes or other restraints for large animals. Containers, cages or pens must be very strongly constructed and well secured. If a suspect animal is first presented at a veterinary clinic, it should be hospitalised away from other animals. Confined suspect animals should be under veterinary care.

Immediate postexposure first aid of dogs should occur in accordance with first-aid guidelines for people (see Section 3.2.3). When handling an exposed animal, handlers should take due care to minimise any risks to themselves.

Destruction of animals

Animals should be destroyed safely and promptly. When selecting destruction methods, preserving opportunities for sampling for disease should be considered. Destroyed animals, and their excretions and secretions, should be handled with care and while wearing appropriate PPE to avoid potential exposure to live virus through abraded skin or mucous membranes (eg eyes and mouth).

Postmortem examinations and specimen collection

Postmortem examinations and specimen collection in rabies cases pose particular hazards to staff. See Section 1.4.3 for further details.

3.3 Strategy for control and eradication

The default policy is to eradicate the pathogen in animals and to prevent spread of infection to humans.

The control and eradication of an outbreak of rabies will require the collaborative efforts of animal and human health services. Wildlife and other relevant authorities should also be involved in the response.

3.3.1 Stamping out

Destruction of the infected animals (eg maintenance hosts) and dangerous contact animals is necessary because infected animals are the only source of spread. However, the cornerstone of effective response to rabies is vaccination, which will be implemented early in an eradication program.

Although the destruction of some animals may be necessary during rabies control programs, care must be taken in any policy that involves widespread destruction of animals. Experience has shown this to be ineffective, costly and unpopular.

Culling of wild or feral animals may be counterproductive. New animals move into depopulated territories, with concurrent behaviours such as increased fighting and territory protection that can lead to an increased rate of infection. However, population management strategies (eg fertility control, environmental modification) to reduce the carrying capacity may be effective in principle.

3.3.2 Quarantine and movement controls

Infected premises

The infected premises (IP) will be immediately declared and quarantine requirements imposed. The area around the IP will be declared as a restricted area (RA), and movement controls will apply. Infected animals will be destroyed.

Restricted area

The movement of susceptible animals into and within the RA will be controlled under a permit system (see Section 4.2).

A trace animal in an RA will be confined so that there is no contact with other susceptible animals. During confinement, it will be vaccinated and observed until it either demonstrates infection or a titre of more than 0.5 international units (IU)/mL postvaccination.

An animal that is known to have been exposed to rabies and that is considered highly likely to be infected (ie a dangerous contact animal) will not be vaccinated, but will be destroyed.

On a case-by-case basis and only where security can be assured, the CVO may decide, in consultation with the diagnostic team, that a suspect animal (an animal not known to have been exposed to rabies, but showing clinical signs requiring differential diagnosis) may not be immediately destroyed. In such cases, a conservative approach would be taken unless available information indicates otherwise. For example, the animal may be held in quarantine, such as on an

owner's property that has been declared a quarantine premises. Appropriate rabies postexposure treatments for the animal would be carried out. The animal would remain in quarantine until its status is determined – either the clinical signs are clearly not due to rabies and it has an adequate vaccinal titre, or it has rabies. However, the risks must be explained to the owners who are responsible for maintaining quarantine. This premises must be declared under appropriate legislation.

If infection in wildlife is considered likely or has occurred, farm animals – particularly working dogs – will be confined, so that contact with wildlife is minimised. Limitation of contact between other farm animals and wildlife may also be appropriate. Although farm animals, such as cattle and horses, are unlikely to transmit rabies to other animals, there is the possibility that humans handling these animals could be infected. Owners should be advised of the risk.

Animal gatherings will be minimised during the outbreak. However, as animals become protected through vaccination programs and immunity develops, gatherings, such as dog shows, may be approved under permit.

See Section 4 for further details on declared areas, and quarantine and movement controls.

Transmission area

Where wildlife populations may be infected and there is a need to implement specific control measures (eg enhanced surveillance and movement controls), the affected jurisdiction's CVO could declare a transmission area (TA) within the declared RA (see Section 4.1.2).

Control area

A control area (CA) may need to be declared. This would consist of a buffer between the RA and other areas free from any controls.

Movement controls may be less restrictive, and animals in the CA may be subject to a vaccination program.

3.3.3 Tracing and surveillance

The rabies virus biotype will be determined as soon as possible (to determine the likely maintenance host). This information will inform tracing and surveillance.

All animals likely to have been exposed to the infected animal during the previous 14 days will be traced (14 days is considered to be the maximum period of virus excretion before clinical signs). They will undergo risk assessment. Animal management will depend on outcomes of the risk assessment and may include destruction, vaccination or quarantine. Management may include an initial period of observation at home.

Susceptible animals within the RA will need to be surveyed. For domestic animals, this may involve visiting and mapping properties, and determining population densities in the RA. Surveillance will be directed towards the detection of clinical signs because there is no reliable method of excluding infection in live animals. Animal owners will need to be encouraged to report signs. Animals will probably

be vaccinated at property visits; this will encourage owner participation in surveillance programs.

A surveillance program will need to be developed for surveillance of wildlife and feral animals. Surveillance may involve spotlight, ground or aerial surveys. This will result in the capture or destruction of any animals exhibiting abnormal behaviour, and the collection of dead animals for laboratory examination. Because rabies is fatal within days of clinical onset, the number of detectably rabid animals in a wild population is always low.

Veterinary reports of animal exposures to suspect rabid animals will be investigated. Reports of human exposures will be reported to human health authorities. The exposed and suspect animals will be either examined and destroyed for laboratory testing, or placed under observation as considered necessary. Any animal showing a change of behaviour should be given a suspect status.

Surveillance will target the maintenance-host species involved in the outbreak. Any species involved in spillover infection from the host species will be preferentially targeted for surveillance over other species.

A public awareness campaign will also be critical to enlisting the support of the public to report sick and dead animals so that relevant specimens can be obtained. Widespread destruction of animals to obtain surveillance samples is not a recommended approach. Further information about public awareness can be found in Section 3.3.11.

Guidelines for wildlife surveillance are further discussed in the AUSVETPLAN **Wild Animal Response Strategy**.

In the case of an infected imported animal confined in or released from official quarantine, the biotype of the infection will need to be quickly determined, initially by consideration of the country of origin and route of travel. Other animals still in the quarantine facility will remain in quarantine. All animals that have been released during the previous 14 days will be traced and undergo risk assessment. Appropriate management of the animals will be instigated. Management of these animals will depend on the risk assessment and may include destruction, vaccination or an extended quarantine period.

See Appendix 2 for further details on surveillance.

3.3.4 Vaccination

In most situations, vaccination is the cornerstone of any rabies-response program. The vaccination protocol will generally be in accordance with the manufacturer's schedule. Any variation to the vaccination protocol will be at the discretion of the state CVO, in consultation with the CCEAD. The vaccine(s) used will have met appropriate regulatory requirements for use in Australia.

The priority for vaccination is the maintenance-host species (eg foxes). Irrespective of the maintenance-host species, any pets that may be linked to the incident will be considered for vaccination to reduce the exposure to humans. Livestock and horses may be vaccinated if the virus begins to cycle in the wild animal populations and if

adequate supplies of vaccine are available. There may be a special need to protect susceptible zoo animals and other groups of animals.

All vaccinated animals will be identified.

An attempt will be made to vaccinate all targeted animals. Vaccination may occur at central points or by house-to-house vaccination, or by a combination of both.

Oral vaccination

Once it has been established that a particular wildlife species is the maintenance host, an oral vaccination program will need to be developed and implemented for the identified species. This will be based on the most recent information on vaccine types, baiting technology, vaccination strategies, host ecology and other relevant information.

Consideration needs to be given to the cost-effectiveness of different options, the efficacy of vaccines and bait types for the host in question, the safety of the vaccine in humans and other nontarget species (eg endangered native animals), the thermostability of the vaccine and bait, and the socioecological conditions that may influence options for vaccination strategies.

Trap-vaccinate-release

Trap-vaccinate-release (TVR) programs may have to be initiated (see Section 1.5.3). TVR may become the only option where an oral vaccine or an efficient bait has not been developed for a species. TVR can be used with a buffer perimeter zone of oral vaccination.

3.3.5 Treatment of infected animals

The treatment of infected animals is ineffective.

3.3.6 Treatment of animal products and byproducts

Because of the fragility of the virus, treatment is not usually necessary.

3.3.7 Disposal of animal products and byproducts

Products or byproducts from infected animals will not be permitted into the food chain. All products from infected animals will be destroyed. The rabies virus is readily destroyed by heat and normal rendering.

Although there is no evidence for transmission of rabies via semen and embryos, these products collected within 14 days before the onset of clinical signs will need to be considered for destruction.

For occupational health and safety considerations, see Section 3.2.

3.3.8 Decontamination

Housing, examination and postmortem areas, as well as hands and clothing, must be decontaminated regularly and kept clean. During decontamination, a high level of hygiene and safety measures for personnel is required.

Contamination with aerosols and saliva is a possibility. All at-risk personnel must take precautions, such as the use of gloves, suitable respiratory protection (eg a P2 respirator) and eye protection.

For further details, see the AUSVETPLAN **Decontamination Manual**.¹³

3.3.9 Wild animal control

Prevention of contact between wild and domestic animals during an outbreak is important to prevent spread. If the disease is detected in wildlife, the population of interest needs to be defined and included in the RA at the earliest possible time. The main concern will be feral dogs and cats, dingoes, and foxes.

Wildlife experts must be consulted in planning, monitoring, surveillance and control programs. Measures should not be introduced that are likely to disperse wildlife.

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

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

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

The following methods will be considered to control rabies in wildlife:

- oral vaccination;
- TVR programs;
- limited and cautious use of population reduction after careful consideration of case-by-case circumstances (note that population reduction is considered to be ineffective and may be counterproductive); and
- combinations of the above.

Population reduction

If there has been a decision to reduce wildlife or feral animal populations in the RA, and the outbreak has been detected early, population reduction needs to be managed concurrently with control measures in domestic animals. When developing population-reduction strategies, consideration needs to be given to the potential risks of rabies spread that can be associated with this strategy.

For further information on wildlife-control and baiting techniques, and other procedures, see the AUSVETPLAN **Wild Animal Response Strategy**.¹³

¹³ www.animalhealthaustralia.com.au/aahc/index.cfm?3C1A77F1-00BD-FCC2-2EAF-1808A3DD71FC

3.3.10 Vector control

Control of vectors is not necessary.

3.3.11 Public awareness and media

Declaration of a case of rabies in Australia is likely to lead to public concern. A public awareness and media campaign will be developed early in the response. The Primary Industries National Communication Network will need to be activated, as it will have a major input. Communication messages will need to be clear about the outbreak response strategy. Information should be provided about the public health aspects of rabies, what constitutes a risk, where to obtain advice, reporting of suspect animals, appropriate clinical management of animal-bite cases, the progress of eradication and events of public interest.

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

To assist the response, the public should be encouraged to report any bites from dogs or other animals, stray dogs or unusual behaviour in wild animals. They will also be encouraged to effectively confine their animals. Guidelines on measures to be adopted by the public should be readily available at veterinary and medical clinics. Poor communication messages could lead to ineffective and unnecessary culling of some animals.

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

All human exposures in the RA must be reported to allow for risk assessment of the person, and tracing, seizure, detention or destruction of the animal involved.

Education campaigns and other information should emphasise the almost invariably fatal course of the disease and the danger of handling rabid animals.

3.4 Funding and compensation

Rabies is classified as a Category 1 disease under the EAD Response Agreement (EADRA).

Category 1 diseases are EADs that predominantly have a serious effect on human health or the environment (eg depletion of native fauna). They may have only minimal direct consequences for the livestock industries. For this category, the

response costs will be borne 100% by governments, with no contribution from livestock industries (refer to the EADRA for details).¹⁴

Information on the cost-sharing arrangements can be found in the **Summary Document**¹⁵ and in the **Valuation and Compensation Manual**.¹⁶

¹⁴ Information about the EADRA can be found at
www.animalhealthaustralia.com.au/programs/eadp/eadra.cfm

¹⁵ www.animalhealthaustralia.com.au/programs/eadp/ausvetplan/ausvetplan_home.cfm

¹⁶ www.animalhealthaustralia.com.au/aahc/index.cfm?3C1A77F1-00BD-FCC2-2EAF-1808A3DD71FC

4 Recommended quarantine and movement controls

4.1 Guidelines for classifying declared areas and premises

4.1.1 Declared premises

Infected premises

An infected premises (IP) is a defined area (which may be all or part of a property) in which rabies exists or is believed to exist, or in which the rabies virus exists or is believed to exist.

Dangerous contact premises

A dangerous contact premises (DCP) is a premises that contains a susceptible animal(s) not showing clinical signs that, following a risk assessment, is considered highly likely to contain an infected animal(s) and present an unacceptable risk to the response if not addressed.

Suspect premises

Suspect premises (SP) is a temporary classification of a premises that contains a susceptible animal(s) not known to have been exposed to an infected animal(s), but showing clinical signs that require an investigation(s).

Trace premises

Trace premises (TP) is a temporary classification of a premises that contains a susceptible animal(s) that tracing indicates may have been exposed to an infected animal(s) and that requires an investigation(s).

4.1.2 Declared areas

Restricted area

Following a risk assessment that takes into account the history of animal movements, a restricted area (RA) will be declared. The RA may be as small as an individual IP or sufficiently large to include home ranges of wildlife or feral animals. The RA will be subject to intense surveillance and movement controls. Movement of susceptible animals out of the area will, in general, be prohibited, while movement into the area would only be by permit (see Section 4.2). Multiple RAs may exist within one control area (CA).

The size of the RA will depend on the ecology of the maintenance host(s). The boundary will take into account the distribution and density of susceptible animals.

Transmission area

The transmission area (TA) is a declared area option that could be implemented by the affected jurisdiction's chief veterinary officer (CVO). It is an area within the declared RA where there may be a need to implement specific control measures. A TA would be located around IPs and be subject to enhanced surveillance and movement controls. The TA would not need to be circular but could have an irregular perimeter, provided that the boundary is initially an appropriate distance from the nearest IP, DCP, SP or TP.

Control area

The CA is a buffer zone between the RA and the noninfected area.

The CA will be a larger declared area around the RA(s). The CA is subject to lesser surveillance than the RA. Movement controls may be less restrictive, and animals in the CA may be subject to a vaccination program. Initially, it may be the entire state or territory, to limit the risk of disease spreading from the RA(s). The boundary of the CA will be adjusted as confidence about the extent of the outbreak increases.

4.2 Movement controls for rabies

4.2.1 Declared premises

Movement of live, susceptible animals (eg dogs, cats, ferrets) from declared premises is prohibited until quarantine is lifted. (Note: the species directly affected will depend on the specific virus biotype of the outbreak.) Other movements will be subject to permit.

Products or byproducts from rabid animals will not be permitted into the food chain, but will be destroyed. Semen and embryos collected within 14 days before the onset of clinical signs may be destroyed.

Movement of people, vehicles and equipment is unrestricted.

4.2.2 Permit conditions

A specific permit (SpP) is jointly completed by the premises owner or farmer, and the relevant government veterinarian or inspector. A printed version must accompany the movement of the relevant animal(s). It may impose preconditions or restrictions on movements.

An SpP will contain the following:

- ownership or agent details;
- place of origin, place of destination and contact details for both;
- the planned route of travel;
- number, species, and identification or description of animals being moved;
- rabies vaccination status (if vaccinated, details provided, including dates of vaccination); and
- owner or agent declaration that

- the animal(s) is healthy, with normal appearance and behaviour
- the premises from which the animal is moved is not under quarantine during the movement, which must be direct to the destination
- the animal(s) will be under the direct control of the person making the declaration and to whom the permit is issued, and isolated from contact with other animals.

A general permit (GP) is completed via a web page by the premises owner or farmer, or their agent. A printed version must accompany the movement of the relevant animal(s). It may impose preconditions or restrictions on movements.

A GP will contain the following:

- ownership or agent details;
- place of origin, place of destination and contact details for both;
- the planned route of travel;
- number, species, and identification or description of animals being moved;
- rabies vaccination status (if vaccinated, details provided, including dates of vaccination); and
- owner or agent declaration that
 - the animal(s) is healthy, with normal appearance and behaviour
 - the premises is not under quarantine
 - during the movement, the animal(s) will be under the direct control of the person making the declaration and to whom the permit is issued, and isolated from contact with other animals.

Note: Where a susceptible animal has moved from the CA to the RA, it will not be permitted to return to the CA or to the outside area while restrictions are in place.

For animals transiting declared premises, permit conditions will include the stipulation that the shipment is not permitted to stop, load or unload anything within the declared premises until the final destination. If travel is from one RA to another RA, the animal(s) must not have been moved within the previous 14 days. Conditions on movement are described in Tables 4.1, 4.2 and 4.3.

Table 4.1 Movement controls for live susceptible animals^a

From \ To	Restricted area	Control area	Outside area
Restricted area	SpP1	Prohibited	Prohibited
Control area	SpP2	GP1	Prohibited
Outside area	Prohibited	GP2	Unrestricted

^a Refer to Table 4.3 for conditions on movement for each permit type

Table 4.2 Movement controls for vaccinated animals^a

From \ To	Restricted area	Control area	Outside area
Restricted area	SpP2	SpP2	Prohibited
Control area	SpP2	Unrestricted	Unrestricted
Outside area	Prohibited	GP3	Unrestricted

^a Refer to Table 4.3 for conditions on movement for each permit type

Note: The vaccinated animal(s) must demonstrate an adequate serological response as an indication that the animal has responded to vaccination.

Table 4.3 Specific and general permit conditions

Permit	Conditions
Specific permit 1 (SpP1)	Travel to be direct to destination and not through a control area or an outside area. Must not stop, load or unload anything during transit.
Specific permit 2 (SpP2)	Travel to be direct to destination and not through an outside area.
General permit 1 (GP1)	Must not stop, load or unload anything during transit. No travel through a restricted area is permitted.
General permit 2 (GP2)	No travel through a restricted area is permitted.
General permit 3 (GP3)	Travel to be direct to destination.

Appendix 1 Key features of rabies

Disease and cause

Rabies is a viral encephalitis (brain inflammation) of mammals (including humans), which is almost invariably fatal. It is usually transmitted by bites and has a variable incubation period of days to years. Globally, the disease is of great public health and animal health significance.

Rabies is caused by infection with any of the viruses of the genus *Lyssavirus*, family *Rhabdoviridae*. The genus *Lyssavirus* is classified phylogenetically into seven genotypes, one of which is called rabies virus (genotype 1). Although endemic lyssaviruses are present in bats in Australia and can cause a fatal encephalitis, which is indistinguishable from rabies in humans, Australia is free from rabies virus.

Distribution

Rabies virus occurs throughout most of the rest of the world except New Zealand, Papua New Guinea, Japan, Great Britain and Ireland, and most of the smaller islands of the world. Recently, there has been an outbreak of rabies in the Indonesian islands of Bali and Flores, which previously had been considered free from the disease.

Species affected

Although most, if not all, warm-blooded animals are susceptible to infection with rabies virus, the susceptibility of Australian native animals to rabies virus is unknown. Note that birds, although warm blooded, are not considered an important species in the rabies cycle.

Rabies disease is maintained in various hosts – such as dogs, foxes and other canines, skunks and bats – that are present in most of the world. Rabies virus biotypes are adapted to specific maintenance hosts such as foxes (fox biotype) and dogs (dog biotype). The maintenance host is highly susceptible to its own biotype but not to other biotypes. Therefore, the probability of establishing infection in a different maintenance host is lower and spread is less effective. For example, a fox biotype will spread more easily among foxes than to other animals.

Domestic dogs are a major maintenance host in much of the world, as they were in Europe and North America before the early decades of the 20th century. Dogs still cause the majority of human rabies in the world.

Spread

Rabies virus is transmitted by contamination of a fresh wound with infected saliva. This is usually from the bite of a rabid animal, but can also result from scratches, or licking of abraded skin or mucous membranes. The virus cannot penetrate intact skin.

The incubation period in animals and humans is highly variable. This is generally of the order of 3–8 weeks, but can vary from 2 days to 6 months or even longer.

Key signs

The clinical syndrome can also be highly variable. The clinical signs of rabies can, in many instances, be subtle and even unremarkable. Clinical signs may change as the disease progresses and may be intermittent. Clinical signs can include excitation; paralysis; loss of normal social and behavioural responses (eg domestic animals will often undergo a personality change and wild animals will often lose their natural fear of humans); unusual vocalisation, chewing and eating abnormal objects (eg dirt and stones); and coma leading to death. Unprovoked aggression leading to biting is a significant factor in transmission to people and other animals.

Specific laboratory diagnostic tests are necessary to confirm rabies infection, as neither clinical signs, nor gross or histological pathology are pathognomonic.

Safe and efficacious vaccines are available for human and animal use, both for pre-exposure and postexposure prophylaxis. Oral vaccination is an important tool to control the spread of rabies in wildlife populations.

Control strategy

Australia's policy is to eradicate rabies in animals and to prevent spread of infection to humans. Destruction of infected animals is necessary because infected animals are the source of spread. Rabies vaccination is an essential part of an eradication program and will be implemented early.

The eradication of an outbreak of rabies will require the collaborative efforts of animal and human health services. Wildlife and other relevant authorities will also be involved in the response.

Summary of policy

Rabies is a notifiable disease in all states and territories of Australia, and is listed by the World Organisation for Animal Health (OIE). The detection of rabies in terrestrial (including bat) hosts in Australia would have significant public health and social impacts, particularly if the disease became widespread, or established in stray or wild animal populations. There may also be ecological and conservation concerns.

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

The default policy is to quickly eradicate rabies to prevent spread to domestic and wild animals, and humans through a combination of strategies including:

- *quarantine and movement controls* on susceptible animals in declared areas to minimise the spread of infection;
- *destruction of infected animals* to remove the most dangerous source of viruses;
- *quarantine, vaccination or destruction* of exposed animals;
- *movement control, vaccination or quarantine* of suspect animals until their rabies status has been clarified;
- *vaccination* of domesticated carnivores (eg dogs, cats, ferrets), other selected species and targeted animal groups in declared areas to protect animals against infection and reduce exposure of humans;
- *monitoring* of wild animals and, if disease establishes in those populations, consideration of implementing a vaccination program;
- *tracing and surveillance* to determine the source and extent of infection, and to provide proof of freedom from the disease;
- *linkage and coordination* of public health and environmental authorities so that they are co-responders; and
- *a public awareness campaign* to facilitate public cooperation from animal owners and the community, including other government and nongovernment authorities.

Successful implementation of the policy will depend on community cooperation and compliance with all control and eradication measures. Advice about immunisation of humans would be provided by public health authorities.

Population reduction of susceptible species is not appropriate.

Appendix 2 Procedures for surveillance and proof of freedom

Surveillance

Surveillance will be necessary:

- when there is suspicion that rabies has entered Australia;
- during an outbreak to determine the extent of the affected area; and
- when the outbreak has been contained, to ensure freedom from further disease and associated quarantine restrictions.

Sampling to detect the limits of rabies is a very difficult matter. Because rabies is fatal within days of clinical onset, the number of detectably rabid animals in a wild population is always low. The best animals to acquire are those that have recently died or become sick. Road-killed and trapped animals are usually not a good source.

To help monitor the disease, members of the public should be encouraged and assisted to report the following:

- unusual behaviour in wildlife or feral animals;
- any animal bite incidents with details of the offending animal; and
- any deaths of dogs, cats and wildlife.

Wildlife experts must be engaged in the planning, monitoring and surveillance programs. The initial concern is to identify the respective hosts related to the specific biotype. This information will inform movement controls, vaccination strategies and surveillance.

Proof of freedom

Proof of freedom from rabies is not as important for trade as it is for many other emergency animal diseases. However, it does have very important social implications. In the case of urban rabies, declaration of freedom one year after the last case was identified would be reasonable.

With wildlife rabies, a longer period would be required because of the limited sampling ability, which essentially consists of examining dead animals or those with clinical signs. In this case, the time for declaration of freedom would depend on the vaccination regime used during the outbreak. Sufficient time must be allowed for vaccinal antibodies to wane and the designed surveillance to detect residual infection.

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). <i>See also</i> Chief veterinary officer (CVO), 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. <i>See also</i> Chief veterinary officer (CVO)
AUSVETPLAN	<i>Australian Veterinary Emergency Plan.</i> 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.
Biotype	A designation of viral type, according to the principal maintenance-host species. There may be multiple variants within a biotype that affect a single species – for example, a skunk rabies biotype, which has three variants, and is found in skunks.
Chief veterinary officer (CVO)	The senior veterinarian of the animal health authority in each jurisdiction (national, state or territory) who has responsibility for animal disease control in that jurisdiction. <i>See also</i> Australian Chief Veterinary Officer
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. <i>See also</i> Cost-sharing arrangements, Emergency Animal Disease Response Agreement.
Confirmed case	A laboratory-confirmed rabies-positive animal.

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.
Control area	A declared area in which the conditions applying are of lesser intensity than those in a restricted area (the limits of a control area and the conditions applying to it can be varied during an outbreak according to need). <i>See Section 4.1 for further details</i>
Cost-sharing arrangements	Arrangements agreed between governments (national and states and territories) and livestock industries for sharing the costs of emergency animal disease responses. <i>See also Compensation, Emergency Animal Disease Response Agreement.</i>
Dangerous contact animal	A susceptible animal that has been designated as being exposed to other infected animals or potentially infectious products following tracing and epidemiological investigation.
Dangerous contact premises	A premises that contains a susceptible animal(s) not showing clinical signs but, following a risk assessment, is considered highly likely to contain an infected animal(s) and presents an unacceptable risk to the response if not addressed. <i>See Section 4.1 for further details</i>
Dead-end host	An infected animal that does not transmit the pathogen to susceptible hosts.
Declared area	A defined tract of land that is subjected to disease control restrictions under emergency animal disease legislation. Types of declared areas include <i>restricted area, control area, infected premises, dangerous contact premises and suspect premises</i> . <i>See Section 4.1 for further details</i>
Decontamination	Includes all stages of cleaning and disinfection.
Depopulation	The removal of a host population from a particular area to control or prevent the spread of disease.
Destroy (animals)	To kill animals humanely.
Disease agent	A general term for a transmissible organism or other factor that causes an infectious disease.
Disease Watch Hotline	A 24-hour toll-free 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 carcasses, animal products, materials and wastes by burial, burning or some other process so as to prevent the spread of disease.
Emergency animal disease	A disease that is: (a) exotic to Australia, or (b) a variant of an endemic disease, or (c) a serious infectious disease of unknown or uncertain cause, or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications. <i>See also</i> Endemic animal disease, Exotic animal disease
Emergency Animal Disease Response Agreement	Agreement between the Australian and state/territory governments and livestock industries on the management of emergency animal disease responses. Provisions include funding mechanisms, the use of appropriately trained personnel and existing standards such as AUSVETPLAN. <i>See also</i> Compensation, Cost-sharing arrangements
Endemic animal disease	A disease affecting animals (which may include humans) that is known to occur in Australia. <i>See also</i> Emergency animal disease, Exotic animal disease
Enterprise	<i>See</i> Risk enterprise
Enzyme-linked immunosorbent assay	A serological test designed to detect and measure the presence of antibody or antigen in a sample. The test uses an enzyme reaction with a substrate to produce a colour change when antigen-antibody binding occurs.
Epidemiological investigation	An investigation to identify and qualify the risk factors associated with the disease. <i>See also</i> Veterinary investigation
Exotic animal disease	A disease affecting animals (which may include humans) that does not normally occur in Australia. <i>See also</i> Emergency animal disease, Endemic animal disease
Exotic fauna/feral animals	<i>See</i> Wild animals
Fomites	Inanimate objects (eg boots, clothing, equipment, instruments, vehicles, crates, packaging) that can carry an infectious disease agent and may spread the disease through mechanical transmission.

General permit (GP)	A movement permit completed via a web page by the premises owner or farmer, or their agent. A printed version must accompany the movement of the relevant animal(s). It may impose preconditions or restrictions on movements.
Genotype	Designation of viral species according to gene sequence, as agreed by the International Committee on Taxonomy of Viruses (ICTV).
Incubation period	The period that elapses between the introduction of the pathogen into the animal and the first clinical signs of the disease.
Index case	The first or original case of the disease to be diagnosed in a disease outbreak on the index property. <i>See also</i> Index property
Index property	The property on which the first or original case (index case) in a disease outbreak is found to have occurred. <i>See also</i> Index case
Infected animal	A live animal that develops clinical signs consistent with the disease and is known to have an epidemiological link (eg in a known infected area or area of epidemiological interest).
Infected premises	A defined area (which may be all or part of a property) in which rabies exists or is believed to exist, or in which the rabies virus exists or is believed to exist. <i>See</i> Section 4.1 for further details
Local disease control centre (LDCC)	An emergency operations centre responsible for the command and control of field operations in a defined area.
Maintenance host	The species that principally sustains the virus cycle; it is highly susceptible to its biotype but less susceptible to other biotypes. Successful control of rabies in the maintenance host will lead to eradication of the virus cycle in the ecological community.
Monitoring	Routine collection of data for assessing the health status of a population. <i>See also</i> Surveillance
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.

Native wildlife	<i>See</i> Wild animals
Negri bodies	Intracytoplasmic inclusion bodies (intracellular structures that are formed by cells in response to viral infection) that are unique to lyssaviruses. They are found mainly in neurons and occur in 50–70% of rabies-infected brains.
OIE Terrestrial Code	OIE <i>Terrestrial Animal Health Code</i> . Reviewed annually at the OIE meeting in May and published on the internet at: www.oie.int/eng/normes/mcode/a_summry.htm
OIE Terrestrial Manual	OIE <i>Manual of Diagnostic Tests and Vaccines for Terrestrial Animals</i> . Describes standards for laboratory diagnostic tests, and the production and control of biological products (principally vaccines). The current edition is published on the internet at: www.oie.int/eng/normes/mmanual/a_summry.htm
Operational procedures	Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.
Owner	Person responsible for a premises (includes an agent of the owner, such as a manager or other controlling officer).
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.
Prevalence	The proportion (or percentage) of animals in a particular population affected by a particular disease (or infection or positive antibody titre) at a given point in time.
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). <i>See also</i> Animal Health Committee
Prodrome	An early sign of developing a disease. The prodrome usually starts before any of the usual symptoms of the disease start. An early or premonitory manifestation of impending disease before the specific symptoms begin.
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.
Restricted area	A relatively small declared area (compared with a control area) around an infected premises that is subject to intense surveillance and movement controls. <i>See</i> Section 4.1 for further details

Risk enterprise	A defined livestock or related enterprise, which is potentially a major source of infection for many other premises. Includes intensive piggeries, feedlots, abattoirs, knackeries, saleyards, calf scales, milk factories, tanneries, skin sheds, game meat establishments, cold stores, artificial-insemination centres, veterinary laboratories and hospitals, road and rail freight depots, showgrounds, field days, weighbridges, and garbage depots.
Sensitivity	The proportion of affected individuals in the tested population that are correctly identified as positive by a diagnostic test (true positive rate). <i>See also</i> Specificity
Serotype	Designation of viral species according to serological reaction against reference lyssavirus antisera. Serotyping as a system of classification for lyssaviruses has been superseded by genotyping.
Specificity	The proportion of nonaffected individuals in the tested population that are correctly identified as negative by a diagnostic test (true negative rate). <i>See also</i> Sensitivity
Specific permit (SpP)	A movement permit jointly completed by the premises owner or farmer, and the relevant government veterinarian or inspector. A printed version must accompany the movement of the relevant animal(s). It may impose preconditions or restrictions on movements.
Spillover host	Infected hosts that belong to a species that do not normally maintain the virus biotype in question (eg a host that is not a maintenance host). Note that spillover host is not synonymous with dead-end host, as spillover hosts may transmit infection to other hosts (although such events are relatively uncommon). <i>See also</i> Dead-end host
Stamping out	The strategy of eliminating infection from premises through the destruction of animals in accordance with the particular AUSVETPLAN manual, and in a manner that permits appropriate disposal of carcasses and decontamination of the site.
State or territory disease control headquarters	The emergency operations centre that directs the disease control operations to be undertaken in that state or territory.
Strain	Designation for a virus type derived from a single isolate. This definition is usually only applied to laboratory propagated viruses (eg Pasteur strain).

Surveillance	A systematic program of investigation designed to establish the presence, extent of 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 not known to have been exposed to a disease agent but showing clinical signs requiring differential diagnosis.
Suspect premises	Temporary classification of premises that contain a susceptible animal(s) not known to have been exposed to an infected animal(s), but showing clinical signs that require an investigation(s). <i>See Section 4.1 for further details</i>
Trace animal	An animal not showing clinical signs, but with an epidemiological link to the disease.
Trace premises	Temporary classification of a premises that contains a susceptible animal(s), which tracing indicates may have been exposed to an infected animal(s), and requires an investigation(s). <i>See Section 4 for further details</i>
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.
- attenuated	A vaccine prepared from infective or 'live' microbes that have lost their virulence but have retained their ability to induce protective immunity.
- inactivated	A vaccine prepared from a virus that has been inactivated ('killed') by chemical or physical treatment.
- recombinant	A vaccine produced from virus that has been genetically engineered to contain only selected genes, including those causing the immunogenic effect.
Variant	A distinct taxonomic entity, as applied to a virus.

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.
Veterinary investigation	An investigation of the diagnosis, pathology and epidemiology of the disease. <i>See also</i> Epidemiological investigation
Viraemia	The presence of viruses in the blood.
Virion	A single individual particle of a virus.
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	A disease of animals that can be transmitted to humans.

Abbreviations

AAHL	Australian Animal Health Laboratory
AUSVETPLAN	Australian Veterinary Emergency Plan
CA	control area
CCEAD	Consultative Committee on Emergency Animal Diseases
CNS	central nervous system
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVO	chief veterinary officer
DCP	dangerous contact premises
DNA	deoxyribonucleic acid
EAD	emergency animal disease
FAT	fluorescent antibody test
GP	general permit
IP	infected premises
IU	international unit
OIE	World Organisation for Animal Health
PCR	polymerase chain reaction
PEP	postexposure prophylaxis
PPE	personal protective equipment
RA	restricted area
RNA	ribonucleic acid
SP	suspect premises
SpP	specific permit
TA	transmission area
TP	trace premises
TVR	trap–vaccinate–release
UV	ultraviolet
WHO	World Health Organization

References

- Aghomo HO, Odyue OO, Tomori O and Ibe M (1989). Isolation of rabies virus from clinically healthy and previously unvaccinated dogs. *Bulletin of Animal Health and Production in Africa* 37:311–136.
- Bek MD, Smith WT, Levy MH et al (1992). Rabies case in New South Wales, 1990: public health aspects. *Medical Journal of Australia* 156:596–600.
- Blanton JD, Self J, Niezgodna M, Faber M-L, Dietzschold B and Rupprecht C (2007). Oral vaccination of raccoons (*Procyon lotor*) with genetically modified rabies virus vaccines. *Vaccine* 25(42):7296–7300.
- Fekadu M (1972). Atypical rabies in dogs in Ethiopia. *Ethiopian Medical Journal* 10:79–86.
- Fekadu M (1988). Pathogenesis of rabies virus infection in dogs. *Review of Infectious Diseases* 10:678–683.
- Fekadu M (1991). Canine rabies. In: *The Natural History of Rabies*, 2nd edition, Baer GM (ed.), CRC Press, Boca Raton, Florida, 367–378.
- Fernandes MV, Wiktor TJ and Koprowski H (1963). Mechanism of the cytopathic effect of rabies virus in tissue culture. *Virology* 21:128–131.
- Geering WA, Forman AJ and Nunn MJ (1995). *Exotic Diseases of Animals: A Field Guide for Australian Veterinarians*, Bureau of Resource Sciences, Australian Government Publishing Service, Canberra.
- Gibbons RV (2002). Cryptogenic rabies, bats, and the question of aerosol transmission. *Annals of Emergency Medicine* 39:528–536.
- Gough PM and Jorgenson RD (1976). Rabies antibodies in sera of wild birds. *Journal of Wildlife Diseases* 12(3):392–395.
- Greene C and Rupprecht C (2006). Rabies and other lyssavirus infections. In: *Infectious Diseases of the Dog and Cat*, Greene C (ed), Elsevier Inc., Philadelphia, 167–183.
- Heymann DL (ed) (2008). *Control of Communicable Diseases Manual*, 19th edition, American Public Health Association, Washington DC, 498.
- Kaplan MM, Wiktor T and Koprowski H (1966). An intracerebral assay procedure in mice for chemical inactivation of rabies virus. *Bulletin of the World Health Organization* 34:293–297.
- Matouch O, Jaros J and Pohl P (1987). Survival of rabies virus under external conditions. *Veterinarni Medicina* 32(LX):669–674.
- Michalski F, Parks NF, Sokol F and Clark HF (1976). Thermal inactivation of rabies and other rhabdoviruses: stabilization by the chelating agent

ethylenediaminetetraacetic acid at physiological temperatures. *Infection and Immunity* 14(1):135–143.

National Association of State Public Health Veterinarians (2008). *Compendium of Animal Rabies Prevention and Control*, United States Department of Health and Human Services, Centers for Disease Control and Prevention, Atlanta, Georgia.

NHMRC (National Health and Medical Research Council) (2008). *The Australian Immunisation Handbook*, 9th edition, NHMRC, Canberra.
www.health.gov.au/internet/immunise/publishing.nsf/Content/Handbook-home

Precausta P, Soulebot JP, Bugand M, Brun A and Chappuis G (1982). Modalities of production and immunity conferred by an inactivated rabies vaccine originating from cell culture. *Comparative Immunology, Microbiology and Infectious Diseases* 5:217–226.

Rupprecht CE, Smith JS, Fekadu M and Childs JE (1995). The ascension of wildlife rabies: a cause for public health concern or intervention? *Emerging Infectious Diseases* 1(4):107–114.

Scott Williams Consulting Pty Ltd (2003). *Persistence of Disease Agents in Carcasses and Animal Products*, Animal Health Australia, Canberra.
www.animalhealthaustralia.com.au/fms/Animal%20Health%20Australia/AUSVETPLAN/WilliamsReport.pdf

Sterner RT, Meltzer MI, Shwiff SA and Slate D (2009). Tactics and economics of wildlife oral rabies vaccination, Canada and the United States. *Emerging Infectious Diseases* 15(8):1176–1184.

Swanepoel R (1994). Rabies. In: *Infectious Diseases of Livestock with Special Reference to Southern Africa*, Coetzer JAW, Thomson GR and Tustin RC (eds), Oxford University Press, South Africa.

Tillotson JR, Axelrod D and Lyman DO (1977). Rabies in a laboratory worker — New York. *Morbidity and Mortality Weekly Report* 26:183–184.

Toma B and Andral L (1977). Epidemiology of fox rabies. In: *Advances in Virus Research*, vol 21, Academic Press, New York.

Veeraraghavan N, Gajanana A, Rangasami R, Oonunni PT, Saraswathi KC, Devaraj R and Hallan KM (1971). Studies on the salivary excretion of rabies virus by the dog from Surandai. In: *Pasteur Institute Annual Report of the Director 1969 and Science Report 1970*, Pasteur Institute of South India, Coonoor, 66.

Wandeler A (1991). Oral immunization of wildlife. In: *The Natural History of Rabies*, 2nd edition, Baer GM (ed), CRC Press Inc, Boca Raton, 485–503.

WHO (World Health Organization) (2007). Oral vaccination of dogs against rabies: guidance for research on oral rabies vaccines and field application of oral vaccination of dogs against rabies, WHO, Geneva.

www.who.int/rabies/resources/guidelines%20for%20oral%20vaccination%20of%20dogs%20against%20rabies_with%20cover.pdf

Winkler WG, Fashinell TR, Leffingwell L, Howard P and Conomy JP (1973). Airborne rabies transmission in a laboratory worker. *Journal of the American Medical Association* 226(10):1219–1221.

Further reading

Aghomo HO, Odyue OO and Tomori O (1990). Experimental infection of dogs and mice with rabies virus isolated from the saliva of unvaccinated clinically healthy dogs. *Bulletin of Animal Health and Production in Africa* 38(3):297–300.

Bacon PJ (ed) (1985). *Population Dynamics of Rabies in Wildlife*, Academic Press, London.

Baer GM (1991). Oral immunization of wildlife. In: *The Natural History of Rabies*, 2nd edition, CRC Press, Boston.

Bogel K (ed) (1984). *Guidelines for Dog Rabies Control*, World Health Organization, Geneva.

Campbell JB and Charlton KM (eds) (1988). Rabies. In: *Developments in Veterinary Virology Series*, Kluwer Academic Publishers, Boston.

Kaplan C, Turner GS and Warrell DA (1986). *Rabies: The Facts*, 2nd edition, Oxford University Press, Oxford.

Larson EL (1996). Hand washing and skin preparation for invasive procedures. In: *Infection Control and Applied Epidemiology*, Bowls B (ed), Association for Professionals in Infection Control and Epidemiology Inc, Washington DC.

Lawson KF, Black JG, Charlton KM, Johnson DH and Rhodes AJ (1987). Safety and immunogenicity of a vaccine bait containing ERA strain of attenuated rabies virus. *Canadian Journal of Veterinary Research* 51:460–464.

Lawson KF, Hertler R, Charlton KM, Campbell JB and Rhodes AJ (1989). Safety and immunogenicity of ERA strain of rabies virus propagated in a BHK-21 cell line. *Canadian Journal of Veterinary Research* 53:438–444.

MAFF (Ministry of Agriculture, Fisheries and Food) (1975). *The Rabies (Control) Order 1974*, MAFF, London.

Raccoon Rabies Task Force Report (1992). The raccoon strain of rabies and recommendations to prevent its becoming established in Toronto, Ontario, Canada, unpublished report, Ministry of Natural Resources, Toronto.

Rosatte RC et al (1993). Scientific and technical review. *Office International des Epizooties* 12(1):95–98.

Rupprecht CE, Dietzschold B and Koprowski H (1994). Lyssaviruses. *Current Topics in Microbiology and Immunology* 187:ix.

Saunders G (1993). *Rabies and Wildlife Review: Consultancy to the Bureau of Resource Sciences*, NSW Agriculture, Sydney.

WHO (World Health Organization) (1973). *Expert Committee on Rabies*, 6th Report, WHO, Geneva.

WHO (World Health Organization) (2009). Recombinant vaccines for oral immunization of wildlife, WHO, Geneva
www.who.int/rabies/vaccines/recombinant/en/index.html (viewed 31 January 2011).

Video and training resources

See the **Summary Document** for a full list of training resources.