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Import Risk Analysis

Review of Conditions for the Importation of Rhinoceros from South Africa

Final Report

July 1999

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AUSTRALIA

IMPORTATION OF RHINOCEROS FROM SOUTH AFRICA IMPORT RISK ANALYSIS PAPER

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EXECUTIVE SUMMARY

This import risk analysis (IRA) reviews the policy on the importation of rhinoceros from South Africa, which was established in 1997. The 1997 import conditions include, as risk management measures, pre-export quarantine (PEQ) in the African horse sickness (AHS)-free area of South Africa and ceritification of area freedom from foot and mouth disease (FMD). Plans at that time were to procure rhinoceros from game parks in Natal.

Since promulgation it became apparent that performance of PEQ in the AHS-free area was too difficult logistically and financially for the project to proceed. The preferred source of rhinoceros is now the Kruger National Park, the only part of South Africa which is not free from FMD. Also there is evidence that the assumptions relating to AHS and FMD, and other pathogens, underlying our earlier risk assessment are unfounded. For these reasons, it was decided to undertake the review.

A draft IRA paper was circulated via AQPM 1999/16 on 1 March 1999. The paper concluded there is a negligible risk of introducing exotic OIE List A or List B diseases other than Rift Valley fever, bovine tuberculosis and heartwater, and a negligible risk of introducing other significant 'African' diseases such as Crimean-Congo haemorrhagic fever and Wesselsbron disease, particularly if adequate vector control is maintained during a period of pre-export isolation. Eleven stakeholders provided comment on the draft IRA paper. These were considered in the finalising of this IRA and the attached revised conditions

There is no record of spread of Rift Valley fever from Africa despite the daily international movement of at least one susceptible species (humans), and the movement of other susceptible vertebrate species from enzootic and epizootic areas to free areas. The disease has not been reported in rhinoceros and there is no convincing evidence that animals other than domestic ruminants are significant in its epidemiology. The risk of introducing this disease through the importation of rhinoceros, even from an enzootic or epizootic area, is therefore considered low. Rift Valley fever is a mosquito-borne viral disease featuring incubation and viraemic periods of only a few days. Risks of entry, establishment and spread of the disease can therefore be reduced to an acceptable (negligible) level by importing at a time when mosquito activity is low or during inter-epizootic periods, and/or by protecting the animals from mosquitoes prior to export and after arrival in Australia.

Heartwater has not been reported in rhinoceros and, although serum antibodies have been found in rhinoceros in one study, the test used is known to have low specificity and it is probable the antibodies detected were to non-pathogenic ehrlichia species. There is no convincing evidence rhinoceros play any part in the epidemiology of the disease. The risk of introducing heartwater is low and becomes negligible with appropriate risk management measures. Heartwater is a non-contagious tick-borne rickettsial disease. Risk of entry is reduced by a requirement for adequate tick control during pre-export isolation and by pre-export testing. The probable absence of competent tick vectors in areas where the imported rhinoceros will be held in Australia means the risk of establishment and spread in Australia is low.

There are few reports of bovine tuberculosis in rhinoceros and the disease has not been confirmed in free-ranging rhinoceros. The risk of introducing bovine tuberculosis is assessed as low. Requirements for certification regarding the source population and for testing reduce the risk to a level AQIS considers acceptable. Permanent confinement of imported animals in AQIS registered zoos reduces risk of establishment and spread.

ABBREVIATIONS AND ACRONYMS

AHV-1	alcelaphine herpesvirus 1
AFFA	Department of Agriculture, Fisheries and Forestry - Australia
AHS	African horse sickness
AQIS	Australian Quarantine & Inspection Service
ARAZPA	Australasian Regional Association of Zoological Parks and Aquaria
ASMP	Australasian Species Management Program
CCHF	Crimean-Congo haemorrhagic fever
Code	OIE International Animal Health Code
DNA	deoxyribonucleic acid
EA	Environment Australia
ELISA	enzyme linked immuno-sorbent assay
FMD	foot and mouth disease
GCAP	Global Captive Action Plan
IFAT	indirect fluorescent antibody test
IRA	import risk analysis
LSD	lumpy skin disease
MCF	malignant catarrhal fever
OIE	Office International des Epizooties (the world organisation for animal health)
OVI	Onderstepoort Veterinary Institute
PAQ	post-arrival quarantine
PCR	polymerase chain reaction
PEQ	pre-export quarantine
PPR	peste des petits ruminants
RVF	Rift Valley fever
SAT	Southern African Territories

DEFINITIONS

The terms *hazard, risk assessment,* and *risk management* etc have the same meaning as in the OIE International Animal Health Code draft Chapter on Import Risk Analysis except that, in this paper, and with the exception of the rhinoceros and any exotic parasites they may carry, the diseases rather than the biological agents that cause them are considered as the hazards.

In this paper risk is considered in relation to the likelihood of hazard entry, establishment and spread and is described as negligible, low, slight, moderate or high. No attempt has been made to assess risk in quantitative terms except that negligible risk is taken to mean no discernible risk.

1. INTRODUCTION

1.1 SCOPE OF THE IMPORT RISK ANALYSIS

Plans for the importation of southern white rhinoceros into Australasian zoos to establish ex-situ breeding groups have been part of the Global Captive Action Plan (GCAP), run under the auspices of the world conservation body, the International Union for the Conservation of Nature (IUCN), and of the Australasian Species Management Program (ASMP) for this species for some years. South Africa was identified as the most appropriate source country. An IRA was conducted in 1995/96 and quarantine requirements for the importation of rhinoceros from South Africa were finalised in March 1997.

For the initial IRA it was assumed the rhinoceros may be infected with, and pose a risk of the introduction of, the serious disease agents of both ruminant livestock and other perissodactyls (horses, zebras and tapirs).

Foremost among these considerations was the assumption, on the grounds that rhinoceros, like horses and zebras, were perissodactyls, that rhinoceros may carry African horse sickness (AHS) virus despite the lack of evidence to support this assumption. As South Africa had identified, and introduced regulatory controls to support and maintain, a defined AHS-free area as part of its efforts to have South African horses accepted for importation into Europe, the conditions developed for import therefore included the requirement that pre-export quarantine (PEQ) be undertaken in the official AHS-free area.

It was also assumed that rhinoceros may harbour foot and mouth disease (FMD) virus despite evidence to the contrary - FMD has never been recorded in rhinoceros. The current conditions require the animals be resident in an area free from FMD for the 6 months prior to export.

Since promulgation of the current conditions it has become apparent that performance of PEQ in the AHS-free area is too difficult logistically and financially for the project to proceed. The best source of rhinoceros is now seen to be the Kruger National Park, the only part of South Africa which is not free from FMD. Furthermore there has been further evidence accrue that the assumptions relating to AHS and FMD, and other pathogens, underlying our earlier risk assessment are unfounded. For these reasons, and to enable this important conservation project to proceed, it was decided to undertake a further IRA to review the current conditions.

A draft IRA paper was circulated via AQPM 1999/16 on 1 March 1999. Eleven stakeholders provided comment. Comments on the draft IRA report and the proposed requirements were generally supportive with all respondents, except for one, indicating they considered the proposed risk management measures were adequate, or more than adequate, to address the risks of introduction of exotic pests and diseases.

AQIS carefully considered all comments, and has further discussed risks with relevant experts in South Africa, and has concluded that the proposed import requirements incorporate sufficient safeguards against the entry of disease agents and pests of quarantine concern. The finalised import requirements are therefore not very different from the requirements proposed in the draft IRA report. There have been some modifications in the testing requirements for Rift Valley fever, hearwater and tuberculosis, and in examination of the animals for freedom from ticks.

1.2 CURRENT QUARANTINE POLICY AND PRACTICE

The importation of animals is subject to the Quarantine Act 1908, the Quarantine (Animals) Regulations and Quarantine Proclamation 1998.

A Bill to amend the Act, the Quarantine Amendment Bill 1998, is now before parliament. The Bill proposes that Section 4 of the Act ('Scope of quarantine') be amended to say:

"In this Act, *quarantine* includes, but is not limited to, measures:

(a) for, or in relation to, the examination, exclusion, detention, observation, segregation, isolation, protection, treatment and regulation of vessels, installations, human beings, animals, plants or other goods or things; and

- (b) having as their object the prevention or control of the introduction, establishment or spread of diseases or pests that will or could cause significant damage to human beings, animals, plants, other aspects of the environment or economic activities."

Proclamation 1998 prohibits the importation of all live animals other than dogs and cats from New Zealand unless the Director of Quarantine has granted a permit to import, and requires that the Director, in deciding whether to grant a permit, consider the quarantine risk and whether the imposition of conditions on the permit is necessary to limit the risk to an acceptable level.

The Quarantine (Animals) Regulations currently require that 'wild and undomesticated animals' imported for exhibition be imported into and held in zoos or circuses registered by AQIS as A or B class zoos or circuses. The Regulations are under review and the current quarantine arrangements for zoos and circuses will change. Nonetheless rhinoceros, and all other imported animals that are deemed to pose a quarantine risk, will continue to be required to undergo post-arrival quarantine (PAQ) in official quarantine stations or in places approved under the Quarantine Act for the performance of quarantine. Places approved under the Act for the performance of quarantine are subject to all the same legislative provisions under the Act as proclaimed quarantine stations. Animals deemed to have vertebrate pest potential will continue to be subject to permanent government control.

A permit to import from the Wildlife Protection Authority of Environment Australia, issued pursuant to the Wildlife Protection (Regulation of Exports and Imports) Act 1982, is also required for live animals other than domesticated species and certain species of rats and mice.

2. HAZARD IDENTIFICATION AND EXPOSURE PATHWAYS

2.1 HAZARD IDENTIFICATION

Rhinoceros, if not appropriately managed, have the potential to have an adverse effect on the environment, ie are a potential hazard in their own right.

Other potential hazards are considered in the following notes. These are:
OIE List A diseases - excluding highly pathogenic avian influenza (fowl plague) and Newcastle disease;

OIE List B diseases - excluding the diseases of birds, lagomorphs and bees, and excluding those diseases of livestock that are present in Australia and for which national official control programs do not apply; and

other serious diseases of ungulates in southern Africa.

List A means the List of transmissible diseases which have the potential for very serious and rapid spread, irrespective of national borders, which are of serious socio-economic or public health consequence and which are of major importance in the international trade of animals and animal products (OIE Code 1997). It is published in Section 6.1. of the Code.

List B means the List of transmissible diseases which are considered to be of socio-economic and/or public health importance within countries and which are significant in the international trade of animals and animal products. List B is published in Section 6.2. of the Code.

The OIE List B diseases of livestock not considered further because they are endemic in Australia, and/or they are listed in the Code as diseases specific to certain domestic species, are anthrax, echinococcosis/hydatidosis, bovine genital campylobacteriosis, enzootic bovine leucosis, infectious bovine rhinotracheitis, trichomoniasis, anaplasmosis, babesiosis (bovine), cysticercosis, dermatophilosis, *Brucella ovis* infection, caprine arthritis/encephalitis, enzootic abortion of ewes (ovine chlamydiosis), equine infectious anaemia, equine rhinopneumonitis, equine viral arteritis, mange, atrophic rhinitis of swine and porcine brucellosis.

The other serious diseases of ungulates and perissodactyls present in southern Africa and considered in this paper are described in *Infectious Diseases of Livestock with special reference to Southern Africa* edited by JAW Coetzer, GR Thomson and RC Tustin and published in 2 Volumes in 1994 by Oxford University Press.

Infectious Diseases of Livestock, and a report on the 'Quarantine Requirements for Zoo Hoofstock' prepared for AQIS by Dr Geoff Gard of the Animal Health Science Branch of the National Offices of Animal and Plant Health and Food Safety, AFFA, are the major references used for much of this IRA.

The potential hazards identified by this process for consideration in the IRA are the following diseases.

OIE List A diseases

foot and mouth disease
swine vesicular disease
rinderpest
peste des petits ruminants
contagious bovine pleuropneumonia
lumpy skin disease
Rift Valley fever
bluetongue
sheep pox and goat pox
African horse sickness
African swine fever
classical swine fever (hog cholera)

OIE List B diseases

Multiple species
Aujeszky's disease, leptospirosis, rabies, Johne's disease, heartwater, screwworm;
Cattle
bovine brucellosis, bovine tuberculosis, theileriosis, haemorrhagic septicaemia, bovine spongiform encephalopathy;
Sheep and goats
caprine and ovine brucellosis (*Brucella melitensis)*, contagious agalactia, maedi-visna, contagious caprine pleuropneumonia, salmonellosis (*S abortus-ovis*), scrapie, Nairobi sheep disease;
Equines
contagious equine metritis, dourine, equine encephalomyelitis (Eastern and Western), equine influenza, equine piroplasmosis, glanders, horse pox, surra, Venezuelan equine encephalomyelitis. epizootic lymphangitis, Japanese encephalitis;
Pigs
trichinellosis, enterovirus encephalomyelitis (ex Teschen disease), transmissible gastro-enteritis.

Other serious diseases of ungulates present in southern Africa
African animal trypanosomiasis (*Trypanosoma brucei, T congolense, T vivax*), besnoitiosis, equine encephalosis, Wesselsbron disease, Crimean-Congo haemorrhagic fever, wildebeest-derived malignant catarrhal fever.

Other potential hazards considered in the IRA are the rhinoceros themselves, and exotic parasites that may be carried by rhinoceros.

Many of the potential hazards identified above can be dismissed from further detailed consideration.

South Africa is free from the following List A diseases:
swine vesicular disease (never reported), rinderpest (last reported 1904), peste des petits ruminants (never reported), contagious bovine pleuropneumonia (1924), sheep pox and goat pox (never reported) and classical swine fever (1918) (OIE 1997).
Furthermore none of these has been reported in rhinoceros (Gard 1999).

Domestic pigs and wild Suidae are the only natural vertebrate hosts of African swine fever virus. Clinical disease occurs in domestic pigs and the European wild boar. Subclinical infection occurs in warthogs and bush pigs (Plowright et al 1994).

South Africa is free from the following List B diseases:
Aujeszky's disease, screwworm, bovine spongiform encephalopathy, contagious agalactia, contagious caprine pleuropneumonia, scrapie (last reported 1972), Nairobi sheep disease, contagious equine metritis, equine encephalomyelitis (Eastern & Western), glanders (1945), Japanese encephalitis, surra, Venezuelan equine encephalomyelitis, transmissible gastroenteritis and enterovirus encephalomyelitis (OIE 1997).
Furthermore, none of these has been reported in rhinoceros and most have not been reported in any wild hoofstock.

After dismissing from further consideration those diseases not present in South Africa and African swine fever, the diseases subjected to further risk assessment below are:
foot and mouth disease (FMD),
lumpy skin disease (LSD),
Rift Valley fever (RVF),
bluetongue,
African horse sickness (AHS),
leptospirosis,
rabies,
Johne's disease,
heartwater,
bovine brucellosis,
bovine tuberculosis,
theileriosis,
haemorrhagic septicaemia,
caprine and ovine brucellosis,
maedi-visna,
dourine,
equine influenza,
equine piroplasmosis,
horse pox,
epizootic lymphangitis,
trichinellosis,
trypanosomiasis,
equine encephalosis,
Wesselsbron disease (WSL),
Crimean-Congo haemorrhagic fever (CCHF) and
wildebeest-derived malignant catarrhal fever (MCF).

2.2 EXPOSURE PATHWAYS

It can be safely assumed that imported rhinoceros will not be permitted, under either Commonwealth or State environmental legislation, release from regulatory control to potentially establish a feral population.

The biological pathway by which an infectious agent may be introduced by an imported animal depends on that species of animal being susceptible to infection with that agent, the agent being present in the country, zone and herd or source population of the animal, the animal itself being infected and the infection persisting until importation, whether the animal is infectious ie whether the agent can be transmitted from or by the infected animal to another, and the exposure of susceptible animals (including humans) to the agent in the importing country. Post-arrival exposure in turn depends on the means of transmission being available eg the presence of competent vectors for agents that are transmitted only by vectors. Risk management measures may be applied at one or more steps in the exposure pathway.

Most of the following notes on the identified potential hazards are based on the text *Exotic Diseases of Animals- a field guide for veterinarians* by WA Geering, AJ Forman and MJ Nunn published for the Bureau of Resource Sciences (BRS) by the Australian Government Publishing Services 1995.

2.2.1 Foot and mouth disease (FMD)

FMD is a highly contagious viral vesicular disease of hoofed animals. FMD virus occurs in the secretions and respiratory aerosols of infected animals and from ruptured vesicles. Transmission may occur by direct contact, aerosols or contact with fomites. The respiratory route is the common portal of entry although susceptible animals may be infected by the oral route or virus may enter through breaks in the skin or mucosae. The amount of virus excreted varies between species.

Pigs liberate vast quantities of airborne virus, ruminants far less. Experimentally infected African elephants did not transmit infection to in-contact animals (Howell et al 1973). Most excretion of virus ceases 4-6 days after lesions develop, when circulating antibodies develop. Some ruminants may become carriers with infection persisting in pharyngeal and cranial oesophageal tissues for up to four years in cattle and African buffaloes. The role of the carrier animal in transmission has been uncertain but there is evidence that transmission from carrier cattle and buffaloes may occur.

2.2.2 Lumpy skin disease (LSD)

LSD is a generalised skin disease of cattle caused by a member of the capripox genus. Biting flies and mosquitoes are thought to transmit the disease mechanically and this mode of transmission is probably more important than direct contact between animals. Viraemia lasts for about 4 days and virus may be demonstrated in saliva for up to 11 days after infection and in skin nodules for up to 33 days (Barnard et al 1994). Pseudo-LSD (Allerton disease) is a relatively benign disease, with similar lesions, caused by bovine herpesvirus-2. It also appears to be spread by insect bites.

2.2.3 Rift Valley fever (RVF)

Rift Valley fever is an acute mosquito-borne viral disease affecting a wide range of vertebrate hosts but mainly ruminant animals and humans. African buffalo, antelopes, monkeys, hippopotami and giraffe are susceptible to infection. RVF virus is a phlebovirus of the family Bunyaviridae. It causes abortions in pregnant animals and a high mortality rate in young animals. Humans are more often infected by handling infected tissues than by mosquito bites. Humans generally suffer an influenza-like illness of varying severity with occasional serious complications.

2.2.4 Bluetongue and
2.2.5 African horse sickness (AHS)

Bluetongue and AHS are non-contagious arthropod-borne diseases of ruminants and equids respectively caused by orbiviruses. The diseases are normally transmitted to vertebrates by insects of the genus *Culicoides* (midges). Dogs may become infected with AHS virus by eating infected horsemeat and may become infected with bluetongue virus by contaminated vaccines and possibly other routes. There is evidence of natural bluetongue and AHS infection of African carnivores and it is hypothesized that this occurs following the ingestion of infected prey (Alexander et al 1994). There is no evidence that infection of carnivores is significant in the epidemiology of these diseases. The diseases do not spread or persist in the absence of competent vectors.

2.2.6 Leptospirosis

Leptospirosis is a term for a number of diseases affecting a range of animal species caused by some serovars of spirochaete bacteria of the genus *Leptospira*. Major pathogenic serovars including *hardjo*, *pomona*, *hyos* and others are found in Australia. Under current Australian animal quarantine policy, risk management measures are applied to prevent the entry,

establishment and spread of *L interrogans* var *canicola* but not other serovars. Leptospires persist in the kidneys and are normally transmitted by ingestion or through the the skin or mucous membranes following contact with water contaminated by infected urine. Semen is also a vehicle of transmission.

2.2.7 Rabies

Rabies is a fatal viral encephalitis caused by a lyssavirus. All warm-blooded animals are susceptible to infection. Transmission is by contamination of a fresh wound with infected saliva, usually by the bite of a rabid animal and almost invariably that of a dog, cat, fox, bat or another carnivore. These animals are the main reservoir hosts. Comparatively few species are good vectors of rabies virus and fewer are reservoir hosts.

2.2.8 Johne's disease

Johne's disease is an enteric disease of a number of ruminant species caused by *Mycobacterium paratuberculosis*. It is characterised by chronic infection and difficulty in diagnosing pre- or sub-clinical infections. It is mainly spread by the faecal-oral route. Viable bacteria may persist on pasture for months.

2.2.9 Heartwater

Heartwater is an acute non-contagious tick-borne disease of ruminants caused by *Cowdria ruminantium*, a member of the *Ehrlichia* group of the family Rickettsia. It is spread by ticks of the genus *Amblyomma*. Entry with an imported animal may result from the animal being either infected with *C ruminantium* or being infested with infected ticks, or both. If an imported animal is infected but tick-free, establishment and spread will depend on there being a competent tick vector in the importing country and such ticks gaining access to the imported animal and subsequently to other susceptible animals.

2.2.10 Bovine brucellosis

Bovine brucellosis is a bacterial disease mainly of ruminants caused by *Brucella abortus*. It is an important zoonosis. Transmission is usually by ingestion of feed or water contaminated by infected uterine fluids or placenta following abortion or parturition. Bulls excrete brucellae in their semen and artificial insemination is a recognised route of transmission although transmission rarely occurs by natural mating. Humans become infected by handling infected cows or their tissues or discharges, or by drinking raw milk from infected cows.

2.2.11 Bovine tuberculosis

Bovine tuberculosis is a chronic contagious bacterial disease caused by *Mycobacterium bovis*. Although it is predominantly a disease of cattle and buffaloes, many species are susceptible to infection. Lesions are most common in the lungs but may be found in many parts of the body. Transmission is generally by the respiratory or oral routes.

2.2.12 Theileriosis

Theileriosis is a non-contagious tick-borne protozoal disease of cattle and buffaloes. Major pathogenic species are *Theileria parva* and *T annulata.* The latter does not occur in southern Africa.

2.2.13 Haemorrhagic septicaemia

Haemorrhagic septicaemia is a specific form of acute pasteurellosis in cattle and buffaloes caused by certain strains of *Pasteurella multocida*. It is primarily a disease of animals under stress. Transmission is by direct contact between animals or through contaminated feed or water. In endemic areas about 2% of healthy cattle and buffaloes carry the organism in their tonsils.

2.2.14 Caprine and ovine brucellosis

Caprine and ovine brucellosis is a contagious disease of sheep and goats caused by *Brucella melitensis*. Like bovine brucellosis, it is an important zoonosis. Infection occurs through the nasopharynx or occasionally through abraded skin. Aborted foetuses, placentae and foetal fluids are important sources of infection. Human infection most frequently results from ingestion of contaminated milk, other dairy products or uncooked meat, or from handling aborting animals.

2.2.15 Maedi-visna

Maedi-visna virus is a lentivirus which causes the slowly progressive diseases maedi (dyspnoea) and visna (wasting) in sheep, and to a lesser extent, goats. It spreads by direct contact between animals.

2.2.16 Dourine

Dourine is a venereally transmitted trypanosomal disease of horses and donkeys caused by *Trypanosoma equiperdum*.

2.2.17 Equine influenza

Equine influenza is an acute, highly contagious respiratory disease of horses and other equids caused by type A influenza viruses. Equine influenza A viruses are classified as subtypes equine1 and equine 2 and strains occur within the subtypes. All recent major epidemics have been due to subtype 2 viruses.

2.2.18 Equine piroplasmosis

Equine piroplasmosis is a non-contagious tick-borne protozoal disease of equids caused by *Babesia equi* and *B caballi*. Transmission may occur iatrogenically through contaminated syringes and needles. Recovered horses may become chronic carriers capable of re-infecting ticks.

2.2.19 Horse pox

Horse pox is an economically unimportant disease of horses caused by one or more viruses. The epidemiology is uncertain. Transmission is thought to occur by direct contact. The role of biting insects is unknown.

2.2.20 Epizootic lymphangitis

Epizootic lymphangitis is a chronic fungal disease of horses and mules, and, less commonly, donkeys and camels, caused by the small fungus *Histoplasma capsulatum* var *farcinosum*. The organism is spread by direct contact, or by contamination of skin wounds or abrasions by flies or dirty grooming or harness equipment.

2.2.21 Trichinellosis

Trichinellosis is a helminth disease of mammals caused by the nematode *Trichinella spiralis*. The adult worms are found in the small intestine and larvae encyst in muscle. The larvae are liberated, and develop into adults, when infected muscle tissue is eaten by a susceptible host. All mammals are reported to be susceptible to trichinellosis but infestation is, naturally, most common in carnivores and omnivores (Gard 1999).

2.2.22 African animal trypanosomiasis

African animal trypanosomiasis (nagana) are the diseases caused by the protozoa *Trypanosoma brucei, T congolense* and *T vivax*. Other trypanosomal diseases considered separately include surra (*T evansi*) and dourine. With the exception of dourine, the trypanosomes are trasmitted from host to host by haematophagous insect vectors. Surra does not occur in southern Africa. Nagana is associated with tsetse flies (*Glossina* spp). *T vivax* is found in Mauritius and South

America in the absence of tsetse flies and is apparently spread in those areas by biting flies (*Tabanus* and *Stomoxys* spp).

2.2.23 Equine encephalosis

Equine encephalosis is a non-contagious arthropod-borne disease of horses caused by an orbivirus and spread by *Culicoides*.

2.2.24 Wesselsbron disease (WSL)

WSL is an acute mosquito-borne flavivirus infection of sheep, cattle and goats that may lead to relatively high mortalities in new-born lambs and kids and congenital malformations of the central nervous system in ovine and bovine foetuses. The principal vectors are aedine mosquitoes. It is a zoonosis and in humans manifests as an influenza-like illness.

2.2.25 Crimean-Congo haemorrhagic fever (CCHF)

CCHF is a tick-borne viral disease mainly of humans though a large number of mammalian species may become infected. Members of three genera of ixodid ticks, *Hyalomma, Dermacentor* and *Rhipicephalus*, have been shown capable of transmitting the infection but the coincidence in distribution of CCHF virus and *Hyalomma* ticks strongly suggests that members of this genus are the most important vectors (Swanepoel 1994).

2.2.26 Wildebeest-derived malignant catarrhal fever

Wildebeest-derived malignant catarrhal fever (MCF) is a disease of cattle that have been exposed to wildebeest. It is caused by a herpesvirus (Alcelaphine herpesvirus 1 or AHV-1). Cattle and domestic buffalo are susceptible to disease and a number of other species have been identified as potentially susceptible including Asiatic cattle and members of the Cervidae.

2.2.27 Exotic parasites

Exotic ticks or other parasites introduced with imported animals may, if they find susceptible hosts, establish as unwanted pests (hazards) in their own right.

3. RISK ASSESSMENT AND RISK MANAGEMENT OPTIONS

Relatively less is known about the susceptibility of wildlife to the important diseases of livestock, and of the validity of diagnostic procedures, than is the case with livestock species. However much is known. South Africa has a cadre of State, wildlife and research and diagnostic veterinarians that ensure that local diseases that affect wildlife are as well known, investigated, diagnosed, researched and reported as anywhere in the world. Kruger National Park is particularly well served with National Parks veterinary staff and, as Senior State Veterinarian, one of the world's pre-eminent wildlife veterinarians. The prompt diagnosis and reporting of Rift Valley fever recently (see 3.1.3 below) supports these observations.

The research and diagnostic services provided by ARC-Onderstepoort Veterinary Institute (OVI) are world-renowned and are well supported by the Universities and other laboratories and institutions. The State veterinary service, the Directorate of Animal Health, has also long been held in high regard. Australia can have confidence that its import requirements will be met thus, in a general sense, reducing the risks of entry of diseases of concern.

Risks are assessed, and risk management options considered, for each identified hazard, on the basis of what is reported in the scientific literature, and on advice given to the author of this paper during visits to Zimbabwe in 1992 and South Africa in 1995 and 1998, and in personal communications with relevant experts in a number of countries since.

3.1 RISKS OF ENTRY, ESTABLISHMENT AND SPREAD, AND CONSEQUENCES, FOR EACH HAZARD

3.1.1 Foot and mouth disease (FMD)

FMD is a disease of cloven-hoofed animals. Many wild cloven-hoofed species are susceptible, as are Asian elephants (*Elephas maximus*), hedgehogs and some rodents. It has never been reported in any rhinoceros species or other perissodactyls. Bengis and Erasmus (1988) state that African elephants (*Loxodonta africana*) and perissodactyls appear to be insusceptible to natural infection with SAT types of FMD virus. No antibodies were found in over fifty sera from white rhinoceros in Kruger National Park (RG Bengis pers comm 1998).

African elephants have been infected experimentally by severe challenge but viraemia was brief and there was no spread to close contacts (Howell et al 1973). By analogy, in the extremely unlikely event rhinoceros do become infected, the risk of establishment and persistence in animals in PEQ is considered low.

Taking all this into consideration, the risk of entry, establishment and spread with imported rhinoceros is considered negligible.

The economic effects of an outbreak of foot and mouth disease in Australia, even on a small scale, would be enormous to individuals, the farming industry as a whole and subsidiary and support industries. The potential cost has been estimated at 3.5% of GDP and 0.6% in aggregate employment for the first year, equating to a one percentage point increase in unemployment. The loss of export earnings in the first year was estimated in 1991 at $2000 million. Markets would be closed to Australian exports for cloven-hoofed animals and their products. The export of grain and other feedstuff would also be affected.

3.1.2 Lumpy skin disease (LSD)

LSD is a disease of cattle. Pastoret et al (1988) and Bengis and Erasmus (1988) both state that LSD is not a natural infection of wildlife although giraffe and impala are susceptible to experimental infection. Barnard (1997) failed to find antibodies in the sera of 6 white and 6 black rhinoceros tested in South Africa.

Risk of entry with imported rhinoceros is considered negligible. Viraemia is transient (Barnard et al 1994). PEQ in facilities remote from cattle will reduce risk of entry even further. PAQ in isolation from cattle will ensure risk of establishment and spread is low to negligible.

The consequences of establishment and spread would be serious. If significant spread occurred prior to recognition and the implementation of control measures, morbidity in cattle herds may be high. Early recognition should provide a reasonable chance of eradication. Slaughter of infected and potentially exposed animals would mean the costs of eradication would be significant. There may be loss of markets with associated downturns in the rural economy.

3.1.3 Rift Valley fever

RVF affects mainly domestic ruminants and man but a number of wildlife species are susceptible to infection. Pastoret et al (1998) list species which may be infected with RVF virus as African buffalo, springbok, blesbok, hippopotamus, African elephant, monkeys and rodents. Bengis and Erasmus (1988) report antibody in hippopotami and elephant, and abortions in springbok and blesbok during epidemics. The disease has never been reported in rhinoceros but Anderson and Rowe (1998) report antibody in black and white rhinoceros in Zimbabwe, and in other species including buffalo and waterbuck.

RVF has been intensively studied in a number of species. Viraemia in ruminant livestock may last up to seven days after infection and virus persists in visceral organs of sheep for up to 21 days (Swanepoel and Coetzer 1994). High viraemic titres occur in domestic ruminants and humans and viraemia of similar intensity and duration has been demonstrated in laboratory and wild rodents. Viraemia of lower intensity and shorter duration has been detected in some other animals that have been studied (Swanepoel and Coetzer 1994).

Epidemics of RVF have occurred in southern Africa at intervals of 5 to 20 years. It is currently postulated that RVF virus in sub-Saharan Africa is maintained in inter-epidemic periods principally by transovarial transmission in aedine mosquitoes and that epidemics are precipitated by abnormally heavy rains leading to explosive increase in vector populations (Swanepoel and Coetzer 1994). Pretorius et al (1997) found evidence of seroconversion in small terrestrial mammals in South Africa following floods in 1988, supporting this hypothesis. RVF has remained confined to Africa despite the daily international movement of at least one susceptible species (humans) from enzootic and epizootic areas, and the movement of other susceptible vertebrate animals from these areas. This suggests that movement of vertebrate animals does not spread the disease. Wind-borne movement of vectors has been incriminated in long-distance spread.

Turell and Kay (1998) evaluated the ability of selected Australian strains *Aedes* and *Culex* mosquitoes to function as potential vectors of RVF virus should the virus be introduced into Australia. They found that several species were susceptible and able to transmit RVF virus to hamsters and mice indicating the potential for RVF epizootics to occur in Australia.

The last major epidemic in South Africa occurred in 1974-76 and, until 1999, the disease had not been diagnosed in that country since 1981. RVF was confirmed in African buffalo, giraffe, waterbuck and humans in January/ February 1999 (Swanepoel 1999) in and near the Kruger National Park.

The risk of spread of RVF with the movement of any vertebrate animals is clearly low. The risk of introduction through the importation of rhinoceros from South Africa is assessed as negligible unless importation takes place directly from an affected area during an epizootic. If rhinoceros are imported direct from Kruger National Park during an epizootic in that area, and if rhinoceros are susceptible to infection as suggested by the serological survey of Anderson and Rowe in Zimbabwe, the risk of entry may not be negligible and risk management measures may be warranted.

In view of the work of Turell and Kay, there may be a risk of establishment and spread **if** rhinoceros become infected and **if** they develop a viraemia.

The consequences of establishment and spread of RVF in Australia would be severe. An uncontrolled outbreak may cause serious losses in the sheep, cattle and goat industries with associated local economic effects (AUSVETPLAN). Further costs would accrue from the application of control and eradication measures.

If the disease became endemic, continuing economic loss would occur due to reproductive losses, mortalities and the cost of ongoing vaccination. Permanent loss of some markets would be likely with an associated down turn in the rural economy.

The disease in humans can be severe and mortalities of 2-18% have been reported. In a large epidemic the costs of medical care and the social impact of deaths may be serious.

3.1.4 Bluetongue

Bluetongue is a disease of ruminants and has never been reported in rhinoceros or other perissodactyls. Barnard (1997) found no antibodies in the sera of 20 white and 20 black rhinoceros tested in South Africa.

Viraemia is transient in ruminants - normally less than 4 weeks in cattle (up to 8 weeks in exceptional cases), and less in sheep.

The risk of entry is considered negligible. Risk of establishment and spread, particularly if appropriate risk management measures are applied eg PEQ and/or PAQ in a vector-free area for longer than the maximum viraemic period, is considered negligible.

The consequences of entry and establishment of exotic serotypes of bluetongue virus may be serious if those serotypes are more pathogentic for sheep than Australian bluetongue viruses and/or if they are more efficiently transmitted by *Culicoides brevitarsis* or if they are transmitted by vectors other than those known to be competent vectors of Australian serotypes.

3.1.5 African horse sickness (AHS)

AHS is a disease of equids. It has never been reported in rhinoceros, and AHS virus has not been isolated from them. Barnard (1997), in his survey of sera collected from 1993-95, found no antibodies in 66 white and 36 black rhinoceros using an ELISA. ELISA antibodies have been found in rhino sera at low titre on other occasions but these sera have been negative on virus neutralisation tests (RG Bengis pers comm 1998; GH Gerdes & R Williams pers comm 1998).

Viraemia in horses is short - normally 4-8 days. It may be up to four weeks in zebras.
It is considered most unlikely rhinos develop a detectable viraemia or a viraemia capable of infecting culicoides. Even if an infected animal was imported, AHS could not become established unless a competent vector fed on that animal very soon after its arrival and passed the infection to a susceptible host.

Culicoides brevitarsis, the most widespread bluetongue vector in Australia (albeit a relatively inefficient one), is a member of the Avaritia group which includes *C imicola*, the major vector of AHS in South Africa. *C brevitarsis* is closely related to *C bolitinos* which may also be a competent vector in South Africa. For the sake of this IRA, it is therefore assumed that *C brevitarsis* may be a competent vector. Other species of culicoides identified in Australia are less likely to be competent vectors, particularly species with a more southerly distribution than *C brevitarsis*. The distribution of *C brevitarsis* in Australia is well known and the ecology of midges well understood. Prevention of exposure of imported animals to these midges for a defined period following importation can be readily achieved.

The risk of entry of AHS virus is low and with the use of appropriate risk management, eg protection from vectors during PAQ for longer than the viraemic period, the risk of establishment and spread is negligible.

The consequences of an outbreak of AHS would be severe. The severity will vary with the extent of the outbreak. Costs would accrue from disruption to industry activities and loss of markets during control and attempted eradication. The consequences of the establishment of AHS in Australia would be dire. If *C brevitarsis* is an efficient vector, and AHS became established, the costs to the Australian horse industry could be enormous arising from costs of control and possible permanent loss of market access. The effect on trans-Tasman movement of horses alone would have a huge impact on the thoroughbred industry.

3.1.6 Leptospirosis

Few wild animal reservoirs of leptospiral organisms have been found in Africa despite their high prevalence in domestic stock. A survey conducted in South Africa, in which leptospiral isolation was attempted from the kidneys of 879 rodents of 19 different species, yielded negative results (Hunter & Herr 1994). Accidental hosts are resistant to infection and, in such species, the renal phase is short and inter-species transmission is inefficient.

The risk of entry with imported rhinoceros is low and the risk of establishment and spread is considered negligible.

3.1.7 Rabies

Rabies may occur in any mammal but is transmitted almost exclusively by carnivores and bats. It has never become established in Kruger National Park and has not been confirmed in rhinoceros in southern Africa (Swanepoel 1994).

The risk of entry, establishment and spread with imported rhinoceros is negligible.

3.1.8 Johne's disease

AQIS has found no reports in the literature of Johne's disease in rhinoceros but is aware of the disease having been diagnosed in a captive black rhinoceros. The risk of entry is considered low. Given the conditions and circumstances under which imported rhinoceros will be kept in Australia the risk of establishment is considered low, the risk of spread negligible and the consequences of introduction minor.

3.1.9 Heartwater

Cowdria ruminantium may be found in many species including a range of domestic and wild ruminants, guinea fowl and tortoises (Bezuidenhout et al 1994). Infection has not been confirmed in rhinoceros. Rhinos are hosts to *Amblyomma hebraeum*, the major vector of heartwater in southern Africa, and *Amblyomma sparsum*, an accidental vector which does not normally feed on domestic stock (Bezuidenhout et al 1994; Horak et al 1987).

Kock et al (1992) reported serological evidence for *Cowdria ruminantium* infection in free-ranging rhinoceros in Zimbabwe. They tested sera for antibodies by monoclonal antibody-mediate competitive ELISA and found a high seroprevalence in black rhino from the lower Zambezi Valley (65.6%) and in white rhino from the Hwange National Park (75.9%). They concluded that these findings signified a possible reservoir role for rhinoceros in the epidemiology of heartwater disease but acknowledged that confirmation by isolation of the organism from rhinoceros blood was lacking. There has been no work to date that confirms the serological evidence reported by Kock et al, and the ELISA they used was known to cross react with *Ehrlichia* species (Peter pers comm 1998).

Bengis (pers comm 1998) noted that serological tests for heartwater have poor specificity due to cross reactions with antibodies to *Ehrlichia* spp. and that mice sub-inoculated with whole blood from 'seropositive' rhino did not seroconvert. The problem of cross-reacting antibodies elicited by *Ehrlichia* agents is well known and acknowledged by many authors (Mahan et al 1998; Mondry et al 1998; Savadye et al 1998 and others).

Bengis also noted that clinical heartwater disease has never been reported in rhinoceros, that it is primarily a disease of cloven hoofed ruminants, and that other perissodactyls such as horses are refractory to infection. He further reported that hundreds of rhinoceros have been translocated out of South Africa's heartwater endemic areas to the heartwater free highveld areas, and to

other countries, without any disease associated problems reported in domestic livestock at destination.

The evidence from research into heartwater and from rhinoceros translocations indicates that the risk of entry of *Cowdria ruminantium* with imported rhinoceros is low but the finding of serum antibodies by Kock et al suggests that it cannot be completely discounted. The risk of entry with infected ticks infesting the imported rhinoceros is also low and can be further reduced by appropriate isolation and tick control applied to the animals prior to export.

The risk of establishment will depend on there being a competent vector in Australia. This would require the introduction of African *Amblyomma* ticks unless Australian *Amblyomma* species are capable of becoming vectors. There are few *Amblyomma* species in Australia and most of these are reptile ticks. The major exception is *Amblyomma triguttatum* (four subspecies are recognised) whose main hosts are large macropods but which may infest domestic livestock, feral pigs, humans and dogs. This species occurs in Queensland, NSW and Western Australia (Roberts 1970). It appears not to have been recorded in southern Victoria or South Australia. If animals are held in areas free from *A triguttatum*, the risk of establishment and spread is negligible.

The consequences of establishment in Australia could be very serious for the cattle industry in northern Australia if *A triguttatum* proved to be an able vector as heartwater is one of the most serious diseases of ruminants in endemic areas. Costs of disease control and loss of production would be significant and the loss of markets into south-east Asia would be a severe blow to the industry, particularly in northern Australia.

3.1.10 Bovine brucellosis

Bovine brucellosis is a disease mainly of cattle. Other livestock species, humans and some wild animals may become infected. Several species of wildlife - hippopotamus, zebra, eland and impala - have tested serologically positive but these are thought to be unimportant in the epidemiology of the disease, and there are few records of abortions in wildlife due to *Brucella* (Bishop et al 1994). There have been several serological surveys of wildlife in southern and eastern Africa for brucellosis. Infection has never been reported in rhinoceros (Bengis pers comm 1998). It is probable that domestic animals are responsible for infecting wildlife and not vice-versa (Pastoret et al 1988; Bengis & Erasmus 1988).

Risk of entry is considered to be low. Risk of establishment and spread is considered negligible. Permanent residence in zoos without contact with domestic cattle further ensures the risk to livestock is negligible.

Consequences of establishment and spread - being loss of country freedom status and trade and other consequences of this - would be serious although early recognition should allow prompt eradication and restoration of free status.

3.1.11 Bovine tuberculosis

There have been very few reports of tuberculosis in rhinoceros. The veterinarians in the Kruger National Park and the Hluhluwe/Umfolosi Park carry out an average of 15 white rhinoceros necropsies per year and have never diagnosed a case of bovine tuberculosis in this species even though the disease is endemic in Cape buffalo in the Parks (Bengis pers comm 1998). Similarly, no evidence of tuberculosis has been found in rhinoceroses in a large number of necropsies in Zimbabwe (MD Kock pers comm 1992). There have been two reports of mycobacteriosis in free

ranging black rhinoceros in Hluhluwe Game Park in Natal and some reports of bovine tuberculosis in captive rhinoceros in zoos in the USA (Stetter et al 1995; Mann et al 1981).

Based on the low reported incidence of the disease and on the necropsy evidence in South Africa and Zimbabwe, the risk of entry of *M bovis* is low. Because imported animals will be confined in AQIS registered zoos, and almost certainly in the major, high security zoos whose collections are remote from domestic livestock, with few in-contact animals, the risk of spread to, and establishment in, animal populations outside the zoo would be low even in the unlikely event an infected animal was imported.

The consequences of re-establishment of bovine tuberculosis in Australia would be serious as it would result in the loss of country freedom status, and consequent damage to some export markets, until such time as the disease was again eradicated.

3.1.12 Theileriosis

Theileriae are ixodid tick-transmitted protozoan parasites of bovids. Of the pathogenic species, *T annulata* (tropical theileriosis), does not occur in southern Africa. *T parva parva* (East Coast fever) occurs in eastern and central Africa, *T parva lawrencei* (corridor disease) occurs in South Africa and *T parva bovis* (Zimbabwe theileriosis) in Zimbabwe. These theileriae infect cattle and buffalo but have not been reported in other wildlife species (Lawrence et al 1994). They are transmitted by the ticks *Rhipicephalus appendiculatus* and *R zambeziensis*, neither of which occur in Australia. *R sanguineus*, which is present in Australia and in southern Africa, is not recorded as a vector of *T parva.*

Unidentified babesia and theileria-like piroplasms have been seen in blood smears from rhinoceros (Bigalke et al 1970; Bengis pers comm 1998). There is no evidence that these piroplasms infect other species (de Waal pers comm 1998). There is no evidence that rhinoceros become infected with the pathogenic species found in cattle and buffalo. The risk of entry, establishment and spread of theileriosis through the importation of rhinoceros, other than by the carriage on them of infected ticks, is therefore considered negligible.

There is a low risk that infected ticks carried by the imported animals could introduce infection. Establishment and spread would then depend on the introduced infected ticks gaining access to susceptible bovine hosts in Australia. The risks of this happening in the Australian zoo environment are low. Effective tick control during PEQ and PAQ renders the risks negligible.

3.1.13 Haemorrhagic septicaemia

Haemorrhagic septicaemia is an acute bacterial disease principally of cattle and buffalo. It has also been reported in pigs, sheep, goats, horses, donkeys, camels and Indian elephants. There are few reports of disease in wildlife and none in rhinoceros. The disease has only been reported once in South Africa - in calves in the north-western Transvaal (Bastianello & Nesbit 1994).

Risk of entry, establishment and spread with the importation of rhinoceros from South Africa is considered negligible.

3.1.14 Caprine and ovine brucellosis

B melitensis infects mainly sheep and goats. It may infect humans causing undulant fever. There are few reports of infection in sheep and goats in South Africa, few reports of infection in wildlife, and none in rhinoceros or other perissodactyls.

Risk of entry, establishment and spread through importation of rhinoceros is considered negligible.

3.1.15 Maedi-visna

Maedi-visna has not been reported in wildlife. Its occurrence in South Africa is listed as 'exceptional' (OIE 1997).

Risk of entry, establishment and spread through importation of rhinoceros is negligible.

3.1.16 Dourine

Dourine is a venereally transmitted disease of equids. It has not been reported in rhinoceros or other wildlife.

Risk of entry, establishment and spread is considered negligible.

3.1.17 Equine influenza

Equine influenza is a disease of horses, mules and donkeys. It has not been reported in rhinoceros. There was an outbreak of equine influenza in South Africa in 1986. The disease was controlled and, it would appear, eradicated. There is no evidence that zebras became infected or that the virus persists in South African horses. Barnard (1997) found no antibodies in zebras (80 samples, or in 20 white and 10 black rhinoceros and comments that the "negative results substantiate observations that the latter diseases (including equine influenza) are absent in South Africa."

Risk of entry, establishment and spread is considered negligible.

3.1.18 Equine piroplasmosis

There is no evidence that these organisms infect rhinoceros but, as equine piroplasmosis is endemic in South Africa, the entry of infected ticks with imported rhinoceros is theoretically possible. Effective pre-export tick control would reduce the risk of entry from low to negligible.

The vectors of equine piroplasmosis in southern Africa are the ticks *Rhipicephalus evertsi evertsi* (*Babesia equi* and *B caballi*) and *Hyalomma truncatum* (*B caballi* only). Transmission by *Rhipicephalus sanguineus*, which is present in Australia and southern Africa, has been reported but it is now believed the tick was misidentified and was, in fact, *R turanicus*, and that *R sanguineus* is not a competent vector. Confinement in major zoos and the almost certain absence of competent tick vectors in Australia means the risk of establishment and spread is negligible.

3.1.19 Horse pox

Horse pox has not been reported in South Africa (OIE 1997). Pox viruses normally exhibit a high degree of host specificity.

Risk of entry, establishment and spread is considered negligible.

3.1.20 Epizootic lymphangitis

Epizootic lymphangitis is a rare chronic fungal disease of horses. It has been reported in camels but not in rhinoceros or other wildlife species. Occurrence in South Africa is described as 'exceptional' (OIE 1997). Rhinoceros will, in any case, be maintained in zoos and have no contact with horses.

Risk of entry, establishment and spread is considered negligible.

3.1.21 Trichinellosis

Trichinellosis has not been reported in rhinoceros or other large wild herbivores (Pastoret et al 1998) and infection of rhinoceros is most unlikely. For establishment and spread to occur, the meat of an infected animal must be eaten. Feeding of casualty animals to zoo carnivores is not generally practised in the major Australian zoos and can be easily prevented in the case of imported hoofstock.

Risk of entry, establishment and spread is considered negligible.

3.1.22 African trypanosomiasis

Trypanosomiasis has been described in both black and white rhinoceros in East Africa and Zimbabwe (Mihok et al 1992, 1994; Clausen 1981).

The pathogenic trypanosomes of livestock in southern Africa are the salivarian trypanosomes *T congolense, T brucei* and *T vivax*. All are associated with tsetse flies. With the exception of some pockets in Kwazulu Natal, South Africa [including Kruger National Park (Bengis pers comm 1998)] is free from tsetse flies and from tsetse associated trypanosomiasis (Connor 1994).

Theoretically all trypanosomes may be mechanically transmitted by biting flies. This is known to happen with *T evansi*, the causative agent of surra, and it is believed mechanical transmission by haematophagous flies other than tsetse has enabled *T vivax* to become established in South America and Mauritius. Mechanical transmission of *T vivax* has not been proven to occur in southern Africa although there is some evidence that it can occur in areas adjacent to tsetse-infested areas. (Connor 1994)

The risk of entry, establishment and spread of *T congolense* or *T brucei* with imported rhinoceros from South Africa is negligible. The risk of entry of *T vivax* is considered low and can be reduced to negligible by sourcing animals from areas certified free from tsetse flies and trypanosomiasis, and/or testing by examination of blood smears or serology. The risk of establishment or spread, in the absence of tsetse flies, is considered low although biting flies are present here.

While establishment of *T vivax* in Australia is considered unlikely, it has occurred in Mauritius and South America in the absence of tsetse flies and the consequences of establishment in Australia, in terms of disease control and differential diagnosis, would be serious. Risk management measures are therefore warranted.

3.1.23 Equine encephalosis

Equine encephalosis is an arthropod-borne viral disease of horses. Disease has not been reported in other species. Barnard (1997) found antibodies in the sera of 28 of 117 zebra and in 4 of 49 elephant. He found no antibodies in the sera of 20 white and 24 black rhinoceros or in other wild animals tested. Incubation and viraemic periods are short - a few days only - and therefore, if rhinoceros were susceptible to infection, risks could be readily managed by protection from vectors during PEQ and/or PAQ.

Risk of entry, establishment and spread with the importation of rhinoceros is considered negligible; protection from insect vectors to address other disease risks further ensures risk is negligible.

3.1.24 Wesselsbron disease

Antibodies have been found in many wild herbivores in South Africa (Swanepoel and Coetzer 1994). Barnard (1997) found antibodies in 26 of 97 white and 15 of 25 black rhinoceros. WSL

virus has not been isolated from any non-domesticated vertebrate other than a gerbil (Swanepoel and Coetzer 1994).

Incubation and viraemic periods are short - a few days only (Theodoridis and Coetzer 1980; Baba 1993).

Risk of entry is low and becomes negligible if there is effective vector control for one to two weeks prior to export. Risk of establishment and spread is low or negligible and is reduced further if there is effective vector control for a short period post-arrival.

3.1.25 Crimean-Congo haemorrhagic fever

Antibody prevalence may be high in cattle sera in some areas. It is generally low in wild vertebrates; highest in the large herbivores (Burt et al 1993). There is serological evidence that it is widely distributed through Africa, Europe and Asia although disease incidence is low (Swanepoel 1994).

Viraemia has been demonstrated in various small mammals of Eurasia and Africa such as hedgehogs, hares and certain rodents, and in domestic ruminants, and some of these hosts have been shown capable of infecting ticks. In all of these species viraemia is short - up to one week - and of low to moderate intensity; it is slightly more intense and of longer duration in humans than in other animals (Swanepoel 1994).

Risk of entry is low and will be negligible if there is effective tick control prior to export. There are no ticks of the genus *Hyalomma* in Australia. Risk of establishment and spread in the absence of *Hyalomma* ticks is negligible although tick control post-arrival may be warranted to further ensure risk is negligible.

3.1.26 Wildebeest-derived malignant catarrhal fever

Wildebeest-derived MCF is a disease of cattle that have been exposed to wildebeest. Cattle and domestic buffalo are susceptible to disease and a number of other species have been identified as potentially susceptible including Asiatic cattle and some members of the family Cervidae. Confirmed cases in African game species have been restricted to kudu, sitatunga, eland and roan antelope although antibodies have been found in some other bovid species. Disease has never been reported in free-living wild animals. Although antibodies have been demonstrated in a number of species of wildlife there is no indication that species other than wildebeest are able to transmit the disease in natural circumstances (Barnard et al 1994).

There is no evidence that rhinoceros or other perissodactyls become infected with Alcelaphine herpesvirus 1 (AHV-1). Barnard (1997) found no antibodies in 9 white and 18 black rhinoceros and no antibodies in zebra, elephant or giraffe.

Risk of entry with the importation of rhinoceros is considered negligible. Risk of establishment and spread is negligible.

3.1.27 Exotic parasites

Rhinoceros in their natural state are frequently infested with a large range of ixodid ticks including those of the genera *Amblyomma, Rhipicephalus, Dermocentor* and *Hyalomma* (Bengis pers comm 1998; Baker and Keep 1970). Many of these are potential vectors or reservoirs of the protozoal and rickettsial diseases of veterinary importance discussed in this paper. Risk of entry is high unless there is effective pre-export treatment. Risk of establishment and spread varies from low to high as host ranges differ for different species. Consequences of establishment and spread are likely to be serious although these, too, will vary between tick species.

Many endoparasites including arthropod larvae, nematodes, trematodes and cestodes are found in rhino. Most appear to be fairly host-specific (Bengis pers comm 1998). Risk of entry is high unless there is effective pre-export treatment. Risk of establishment and spread is low for most but may be moderate to high for some.

3.2 RISK MANAGEMENT FOR EACH IDENTIFIED HAZARD

Risk management measures may include requirements for region, country, zone or herd freedom from specific diseases, pre-export and/or post-arrival quarantine, testing, treatment or protection from disease vectors. A risk management strategy is normally a combination of these.

3.2.1 Foot and mouth disease

As it has been concluded the risk of introduction is negligible, specific risk management measures such as serological tests are not considered necessary. However, because an incursion of FMD would have such serious consequences, the amended conditions require that each animal be serologically tested during PEQ as an added assurance. The extended periods of PEQ and PAQ in isolation from known susceptible species specified in the amended import conditions further ensures there is, effectively, no risk.

3.2.2 Lumpy skin disease

Extended periods of PEQ and PAQ remote from cattle are sufficient to ensure risk is negligible. The amended conditions require a minimum of 60 days PEQ (in reality it will be probably be at least four months) and 60 days PAQ. After completion of PAQ the rhinoceros will continue to have no direct contact with cattle or other domestic livestock.

3.2.3 Rift Valley fever

In view of the recently reported outbreak of Rift Valley fever in the Kruger National Park, some risk management measures are possibly warranted. Measures available include antibody testing (given the short incubation and viraemic periods, sero-positive animals would present negligible risk), vaccination, testing for virus or antigen, performance of the latter part of PEQ in an area free from recent infection, and protection from mosquitoes during the latter stages of PEQ and the early part of PAQ. Protection from vectors may be achieved by conducting PEQ and/or PAQ at a time when mosquitoes are inactive, and/or housing in mosquito protected buildings, or treatment with appropriate and effective insecticides or insect repellants.

The rhinoceros intended for importation will be captured in Kruger National Park during the Autumn months. The quarantine bomas at KNP are excellent and the National Parks veterinarians and wildlife staff there have much experience and expertise in the capture, care and management of rhinoceros for export. As it is desirable that PEQ be undertaken in these facilities, the following risk management measures are prescribed:

(i) Export/import is to take place during the period from 31 July to 31 October. This will ensure that the last 30 days of PEQ (at KNP), and the first 30 days of PAQ (at Werribee), takes place at a time when mosquito activity is minimal. Although KNP is frost free, the winter period is normally dry and relatively insect free (Grobler pers comm 1999). Swanepoel (pers comm 1999) believes the level of transmission in the park would be extremely low or non-existent at this time unless there is unseasonal heavy rain. As noted earlier, epidemics are precipitated by abnormally heavy rains leading to explosive increase in vector populations (Swanepoel and Coetzer 1994).

(ii) The animals will be treated with suitable ectoparasiticides, as required, to prevent insect attack during the latter part of PEQ. Grobler (1999) believes the rhinoceros will be tame enough

by then to allow daily treatments if required but states that long-acting pour-on treatments are also available.

(iii) Certification that RVF has not been diagnosed in the vicinity of the PEQ premises during the 30 days immediately prior to export will be required.

AQIS considers these measures will ensure the risk of entry negligible.

The amended import conditions also require protection from insects, by suitable housing or appropriate use of insecticides, for the first 10 days after arrival in Australia to further ensure risk of establishment and spread is negligible.

3.2.4 Bluetongue

As it is almost certain that rhinoceros do not carry bluetongue virus, the application of specific risk management measures is unnecessary. The amended import conditions require that PAQ take place in bluetongue vector-free areas further ensuring negligible risk.

3.2.5 African horse sickness

As it is most unlikely rhinoceros carry AHS virus, the application of specific risk management measures is probably superfluous. Options include PEQ in an AHS free area, protection from vectors during PEQ, pre-export testing by serology and/or virus isolation, PAQ in a vector free area and protection from vectors during PAQ.

Of these, protection from vectors during PEQ and PAQ will be achieved to some degree by the ectoparasiticidal treatments applied to ensure freedom from ticks and other disease vectors and exotic parasites. The amended import conditions require that PAQ take place in vector free locations. As the major zoos in Australia are located in bluetongue free-areas, this will occur in any case. AQIS considers further risk management measures are not warranted but, as testing is readily available, pre-export serological testing is required as an added assurance.

3.2.6 Leptospirosis

The risk of entry is low, the risk of establishment and spread is negligible and testing and treatment options are unreliable. Specific risk management measures are not considered warranted.

3.2.7 Rabies

No risk management measures are warranted.

3.2.8 Johne's disease

Risk management options include testing and post-arrival isolation from susceptible species. Testing, whether immunological, or by culture, or PCR amplification of DNA, is likely to have low sensitivity; immunological tests are unvalidated in wildlife and most have low specificity. The imported animals will be permanently held in registered zoos in isolation from domestic ruminants while they remain in Australia ensuring risk of spread is negligible. No specific risk management measures are considered warranted. Specific measures are not included in the amended conditions.

3.2.9 Heartwater

A range of diagnostic tests has become available over the last decade. They include the IFAT, ELISAs, Western blot assays, gene probes and PCR assays. The IFAT, the ELISAs and the Western blot lack specificity. Most DNA probes and PCR assays are yet to be validated. The best PCR assays are those based on pCS20 sequence (Mahan et al 1992; M Burridge pers comm

1999) The pCS20 PCR assay has acceptable levels of sensitivity and specificity (Burridge 1997). A single test may not be sufficiently sensitive to detect the low circulating rickettsemias frequently observed in carrier animals and repeat testing may be required (Peter pers comm 1998; Mahan pers comm 1998). A battery of DNA probes has been developed at OVI, where there has been extensive research into heartwater diagnostics and prevention (Allsopp et al 1998), and these can be applied to testing rhinoceros (de Waal pers comm 1998).

Additional methods of testing include blood transmission tests to mice or sheep (AJ deVos pers comm 1999), harvest of any ticks from the animals at the time of capture and testing of these by PCR and/or the feeding of uninfected ticks on the rhinos during PEQ for pick up of infection for onward transmission to susceptible ruminants (Mahan pers comm 1998).

Testing by DNA probes and sheep transmission, and by pCS20 based PCR assay, is specified in the amended conditions. Vigorous tick control during PEQ and again during PAQ is also required. A combination of the best available tests and tick control ensures risk of entry, establishment and spread is reduced to an acceptable (negligible) level.

3.2.10 Bovine brucellosis
Risk of entry, establishment and spread is assessed as negligible. Specific risk management measures are not considered warranted.

3.2.11 Bovine tuberculosis
Certification that tuberculosis has not been diagnosed in the rhinoceros in the source population/s is, given the level of management and disease investigation by wildlife veterinarians in South Africa, considered meaningful and has therefore been included in the amended conditions.

Ante mortem tests in pachyderms are inaccurate and intradermal tuberculin testing is likely to give equivocal results. The previous (1997) protocol specified an ELISA on samples collected 10 days after sensitising the animal with tuberculin. This technique was devised by Dr JRB Flamand of the Natal Parks Board and is being further evaluated by researchers in South Africa (A Michel pers comm 1998). It has been used as a pre-export test for rhinos for other destinations (I Espie pers comm 1998). The sensitivity of the Flamand test has not been established and may be no better than other assays. Some experts suggest it may be of the order of 30% (SL Jones pers comm 1999).

The low sensitivity of the ELISA is acknowledged. A PCR technique has been developed in the Tuberculosis Research Unit at OVI and has been tested extensively with known infected and non-infected buffalo with good correlations. The use of the PCR assay in parallel with the ELISA is expected to substantially improve sensitivity. The Tuberculosis Research Unit has a database of some 60 white rhinoceros ELISA results that support the field observations that tuberculosis does not occur in rhinoceros in the Kruger National Park (A Michel & R Bengis pers comm 1999). Testing by ELISA and PCR assay is specified in the amended conditions.

3.2.12 Theileriosis
The risk of entry through infected rhinoceros is assessed as negligible.

The amended conditions specify acaricidal treatment to ensure freedom from ticks during PEQ and tick treatment again in PAQ which should adequately address any risk of entry, establishment and spread through the introduction of infected ticks.

3.2.13 Haemorrhagic septicaemia;
3.2.14 Caprine and ovine brucellosis;

3.2.15 Maedi-visna;
3.2.16 Dourine; and
3.2.17 Equine influenza
The risks of entry, establishment and spread of these diseases are assessed as negligible and specific risk management measures are not considered warranted.

3.2.18 Equine piroplasmosis
Examination of blood smears can be undertaken but this alone will not necessarily enable identification of any piroplasms seen. Serological tests are available but the tests are not fully validated in rhinoceros. As the available evidence indicates neither *Babesia equi* or *B caballi* infect rhinos, and in the almost certain absence of competent tick vectors in Australia, testing is not considered warranted.

Tick control during PEQ and PAQ is required in the amended conditions and should ensure the risk of entry of ticks, and any micro-organisms they may carry (including babesiae) is negligible, and that the risk of establishment and spread of equine piroplasmosis is negligible.

3.2.19 Horse pox;
3.2.20 Epizootic lymphangitis; and
3.2.21 Trichinellosis
The risks of entry, establishment and spread of these diseases are assessed as negligible and specific risk management measures are not considered warranted.

3.2.22 African trypanosomiasis - *Trypanosoma vivax*
Diagnostic methods include examination of blood smears and buffy coat preparations, and serological tests including an IFAT and both antibody and antigen-detection ELISAs. None of these is likely to have a sufficiently high sensitivity to reliably detect a carrier state. The likelihood of rhinoceros from South Africa carrying trypanosomes is so small that testing specifically for trypanosomiasis is not considered warranted. Certification that trypanosomiasis has not been diagnosed in the source population/s and that the rhinoceros were from an area free from tsetse flies provides sufficient assurance and is included in the amended conditions.

3.2.23 Equine encephalosis
The risk of entry is assessed as negligible. No risk management measures are considered warranted. PAQ in bluetongue vector-free areas of Australia ensures risk of establishment and spread is negligible.

3.2.24 Wesselsbron disease
Effective vector control by appropriate use of insecticides for the last 10 days of PEQ will prevent entry and is required in the amended conditions. Similar requirements for the first 10 days of PAQ will ensure risk of establishment and spread is negligible. Antibody testing is available but will only detect animals that may have been exposed rather than those that are viraemic and is not warranted.

3.2.25 Crimean-Congo haemorrhagic fever
Antibody tests are available but are not considered warranted. By the time antibody is detectable in animals following infection, they will no longer be viraemic.

Effective tick control during PEQ is required in the amended conditions and is sufficient to virtually eliminate risk of entry of CCHF virus. Further tick treatment during PAQ, and the absence of Hyalomma ticks in Australia, will ensure risk of establishment and spread is negligible.

3.2.26 Wildebeest-derived malignant catarrhal fever

The risk of entry, establishment and spread is assessed as negligible. Specific risk management measures are not warranted.

3.2.27 Exotic parasites

Treatment with a suitable acaricide several times during PEQ to ensure the animals are tick-free is specified in the amended conditions. Examination for ticks and acaricidal treament soon after arrival in PAQ is also specified.

There are limited options for deworming and these include intramuscular injection of doramectin, subcutaneous injection of ivermectin, and feeding of medicated feed pellets incorporating fenbendazole for two weeks (Bengis pers comm 1998). The amended conditions specify treatment by one or more of these methods.

4. REFERENCES

Alexander KA, Kat PW, House J, House C, O'Brien SJ, Laurenson MK, McNutt JW, Osburn BI (1995) African horse sickness and African carnivores. *Vet Microbiol* 1995 Nov;47(1-2):133-140

Allsopp MT, Hattingh CM, Vogel SW, Allsopp BA (1998) Comparative evaluation of 16S, map1 and pCS20 probes for the detection of Cowdria and Ehrlichia species in ticks. *Ann N Y Acad Sci* 1998 Jun 29; 849:78-84

Anderson EC and Rowe LW (1998) The prevalence of antibody to the viruses of bovine virus diarrhoea, bovine herpes virus 1, rift valley fever, ephemeral fever and bluetongue and to Leptospira sp in free-ranging wildlife in Zimbabwe. *Epidemiol Infect* 1998 Oct;121(2):441-449

Baba SS (1993) Virological and immunological studies of Wesselsbron virus in experimentally infected red Sokoto (Maradi) goats. *Vet Microbiol* 1993 Apr: 34(4):311-320

Baker MK and Keep ME (1970) Checklist of the ticks found on the larger game animals in the Natal game reserves. *Lammergeyer* 12:41-47

Barnard BJH (1997) Antibodies against some viruses of domestic animals in southern African wild animals. *Onderstepoort J Vet Res* 64:95-110

Barnard BJH, Munz E, Dumbell k, Prozesky L (1994) Lumpy skin disease. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:604-612

Barnard BJH, van der Lugt JJ, Mushi EZ Malignant catarrhal fever. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:946-957

Bastianello SS and Nesbit JW (1994) Haemorrhagic septicaemia. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 2:1180-1183

Bengis RG and Erasmus JM (1988) Wildlife diseases in South Africa: a review. *Rev sci tech Off int Epiz* 1988; 7(4):807-821

Bezuidenhout JD, Prozesky L, du Plessis JL, van Amstel SR (1994) Heartwater. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:688-717

Bigalke RD, Keep ME, Keep PJ (1970) A large Babesia sp. and a Theileria-like piroplasm of the square-lipped rhinoceros. *J South Afr Vet Med Assoc* 41:292

Bishop GC, Bosman PP, Herr S (1994) Bovine brucellosis. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 2:1053-1066

Burt FJ, Swanepoel R, Braack LE (1993) Enzyme-linked immunosorbent assays for the detection of antibody to Crimean-Congo haemorrhagic fever virus in the sera of livestock and wild vertebrates. *Epidemiol Infect 1993* Dec; 111(3):547-557

Clausen B (1981) Survey for trypanosomiasis in black rhinoceros (Diceros bicornis). *J Wildl Dis* 1981 Oct; 17(4):581-586

Connor RJ (1994) African animal trypanosomiasis. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:167-205

Gard GP (1999) OIE List A diseases. In: *Quarantine requirements for zoo hoofstock*. National Offices of Animal and Plant Health and Food Safety, AFFA 10-17

Gard GP (1999) Trichinellosis. In: *Quarantine requirements for zoo hoofstock*. National Offices of Animal and Plant Health and Food Safety, AFFA 43

Horak IG, MacIvor KM, Petney TN, De Vos V (1987) Some avian and mammalian hosts of Amblyomma hebraeum and Amblyomma marmoreum (Acari: Ixodidae). *Onderstepoort J Vet Res* 1987 Sep; 54(3):397-403

Howell PG, Young E, Hedger RS (1973) Foot-and-mouth disease in the African elephant (*Loxodonta africana*). *Onderstepoort J Vet Res* 40:41-42

Kock ND, Jongejan F, Kock MD, Kock RA, Morkel P (1992) Serological evidence for Cowdria ruminantium infection in free-ranging black (Diceros bicornis) and white (Ceratotherium simum) rhinoceroses in Zimbabwe. *Jnl of Zoo and Wildlife Med* 23:409-413

Lawrence JA, deVos AJ, Irvin AD (1994) Theileriosis. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:307-348

Mahan SM, Peter TF, Simbi BH, Burridge MJ (1998) PCR detection of Cowdria ruminantium infection in ticks and animals from heartwater-endemic regions of Zimbabwe. *Ann N Y Acad Sci* 1998 Jun 29; 849:85-87

Mann PC, Bush M, Janssen DL, Frank ES, Montali RJ (1981) Clinicopathologic correlations of tuberculosis in large zoo mammals. *J Am Vet Med Assoc* 1981 Dec 1: 179(11):1123-1129

Mihok S, Olubayo RO, Moloo SK (1992) Trypanosomiasis in the black rhinoceros (Diceros bicornis Linnaeus, 1758). *Rev Sci Tech* 1992 Dec; 11(4):1169-1173

Mihok S, Zweygarth E, Munyoki EN,Wambua J, Kock R (1994) Trypanosoma simiae in the white rhinoceros (Ceratotherium simum) and the dromedary camel (Camelus dromedarius). *Vet Parasitol* 1994 Jun; 53(3-4):191-196

Mondry R, Martinez D, Camus E, Liebisch A, Katz JB, Dewald R, van Vliet AH, Jongejan F (1998) Validation and comparison of three enzyme-linked immunosorbent assays for the detection of antibodies to Cowdria ruminantium infection. *Ann N Y Acad Sci* 1998 Jun 29; 849:262-272

OIE (1997) World Animal Health in 1996

Pastoret P-P, Thiry E, Brochier B, Schwers A, Thomas I and Dubuisson J (988) Diseases of wild animals transmissible to domestic animals. *Rev sci tech Off int Epiz* 1988; 7(4):705-736

Plowright W, Thomson GR, Neser JA (1994) African Swine fever. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:568-599

Pretorius A, Oelofsen MJ, Smith MS, Ryst E van der (1997) Rift Valley fever virus: a seroepidemiologic study of small terrestrial vertebrates in South Africa. *American Jnl of Tropical Medicine and Hygiene* 1997 57:6, 693-698

Roberts FHS (1970) Amblyomma genus. In: *Australian Ticks* Commonwealth Scientific and Industrial Research Organization 109-114

Savadye DT, Kelly PJ, Mahan SM (1998) Evidence to show that an agent that cross-reacts serologically with Cowdria ruminantium in Zimbabwe is transmitted by ticks. *Exp Appl Acarol* 1998 Feb; 22(2):111-122

Stetter MD, Mikota SK, Gutter AF, Monterroso ER, Dalovisio JR, Degraw C, Farley T(1995) Epizootic of Mycobacterium bovis in a zoological park. *J Am Vet Med Assoc* 1995 Dec 15; 207(12):1618-1621

Swanepoel R and Coetzer JAW (1994) Rift Valley fever. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:688-717

Swanepoel R (1994) Crimean-Congo haemorrhagic fever. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock* Oxford University Press 1:723-729

Swanepoel R (1994) Rabies. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:493-550

Swanepoel R and Coetzer JAW (1994) Wesselsbron disease. In: Coetzer JAW, Thomson GR, Tustin RC, editors. *Infectious Diseases of Livestock with special reference to Southern Africa* Oxford University Press 1:663-670

Swanepoel R (1999) Rift Valley fever confirmed in South Africa. *ProMED-AHEAD Digest V99 #13*

Theodoridis A and Coetzer JAW (1980) Wesselsbron disease: Virological and serological studies in experimentally infected sheep and goats. *Onderstepoort J of Vet Res* 1980 47:221-229

Turell MJ and Kay BH (1998) Susceptibility of selected strains of Australian mosquitoes (Diptera: Culicidae) to Rift Valley fever virus. *Jnl of Medical Entomology* 35 (2):132-135