Chapter 12

Disease Concerns for Wild Equids

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12.1 Introduction

12.1.1 Why are diseases a concern?

The translocation of mammals and birds from one region to another for the reinforcement of a population or for reintroduction of a species has become a popular wildlife management technique (Woodford 1993; IUCN 1998). Wild animals are also frequently moved to areas outside of their natural range, for example, for captive breeding or exhibition. Why is an understanding of epidemiology and disease important when considering the movement of wildlife?

When animals are translocated they may "import" new diseases, which can adversely affect the managed species (either the translocated animals or resident animals of the same species), other resident species at the translocation site, or both (Cunningham 1996). The introduction of African horse sickness into Spain in 1987 when several zebra were moved there from Namibia was laden with disastrous results (Rodriguez *et al.* 1992), and symbolises the need for full consideration of diseases and their control when moving wild animals (DeVos 1973; Meltzer 1993; IUCN 1998). Finally, most diseases of domestic equids can be transmitted to wild equids and vice-versa; thus, disease surveillance for conservation programs must be comprehensive (Wemmer *et al.* 1996).

Veterinary involvement in conservation projects can augment problem-solving abilities through an enhanced interdisciplinary approach incorporating clinical disease management, pathology, epidemiology, nutrition, genetics, toxicology, and reproduction (Karesh and Cook 1995). The health of wild populations is more likely to be secure if the conservation team has the ability to identify critical health factors, assess and monitor health status, intervene in crisis situations, develop and apply new technologies, address animal handling and welfare concerns, and provide training (Karesh and Cook 1995).

12.1.2 Summary and objectives

To improve success rates of endangered species conservation efforts, population management requires a multidisciplinary approach. Diseases can have as great an influence on populations as predation, competition, or environmental degradation (Lyles and Dobson 1993). "Disease, because it has profound influences on individual fitness, is a major evolutionary force and an important factor in the maintenance of biodiversity" (Cunningham 1996). Awareness of diseases affecting both wild animals and their domestic relatives will be an important component in the design of successful conservation measures, with precautions needing to be taken to preclude disease transmission in either direction (Lyles and Dobson 1993; Daszak *et al.* 2000).

Here we present information on diseases reported to affect or to be carried by wild equids, both in their natural environment and in captivity. The tables in this chapter are designed to be tools for managers of wild equid populations, providing a historical perspective on the types and distribution of diseases reported in non-domestic equids. The tables are not, however, an attempt to cover all aspects of the veterinary medicine and management of wild equids, but rather are meant to give wildlife managers an appreciation for the need to include "veterinary tools" in their "conservation toolbox." Locally available information on the health status of *domestic equids* in an area of interest should always be sought from veterinary authorities and local animal owners (Woodford and Rossiter 1993).

Viral and bacterial diseases of wild equids are emphasised here, based on available literature. A bibliography on parasitic diseases can be found in Appendix 4. Other medical and surgical conditions are mentioned. The authors acknowledge that, overall, there is still inadequate information on the incidence, distribution, and risks of disease in both captive and wild equid populations (Wolff and Seal 1993). Poisonous plants are not covered in this chapter, and other references should be consulted on this important topic (for example, Vahrmeijer 1981).

Acquisition of data on the infectious diseases of threatened and endangered species can be expedited through cooperative disease surveys of captive and free-ranging animals (Munson and Cook 1993). A minimum information base for this profile, compiled largely from pathology data, would include an inventory of all diseases known to have affected the species, the indigenous microflora (bacterial, viral, and parasitic) of the species, and the immunoserologic profile of pathogens known to affect this and related species (Munson 1991).

The reported diseases of non-domestic equids, both free-ranging and captive, are summarised in Table 12.1 and Table 12.2, respectively. A comprehensive bibliography

Table 12.1. Reported diseases of free-ranging wild equids.

A. MOUNTAIN ZEBRAS Continent of origin: Africa

Hartmann's Mountain Zebra
Equus zebra hartmannae
Country and specific location: Namibia, Khomas Hochland population **Study period/Date reported:** 1973–1974 **Reference:** Joubert 1974

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Tested negative for Anthrax (*Bacillus anthracis*)$_{M}$			Drought, accidents, predation$_{N}$	Spore ingestion, Insect vectors

E. z. hartmannae
Country and specific location: South Africa **Study period/Date reported:** 1974 **Reference:** Penzhorn 1984

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Severe drought$_{N}$	N/A

E. z. hartmannae
Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1974-1992 **Reference:** Lindeque and Turnbull 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$				Spore ingestion, Insect vectors

E. z. hartmannae
Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1975-1990 **Reference:** Berry 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$				Spore ingestion, Insect vectors

E. z. hartmannae
Country and specific location: Namibia **Study period/Date reported:** 1983 **Reference:** Daly *et al.* 1983

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Sarcocystosis (*Sarcocystis* spp.)$_{P}$		Sporocyst ingestion, Sporocyst dispersal by insects possible, N/V

[A]*E. z. hartmannae*
Country and specific location: Namibia **Study period/Date reported:** 1992 **Reference:** Borchers and Frolich 1997

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Equine herpes viruses EHV-1$_{S,}$ EHV-4$_{S,}$ EHV-2$_{S}$					Virus inhalation, Direct contact, N/V

E. z. hartmannae
Country and specific location: Namibia, Etosha National Park and South Africa, Kruger National Park **Study period/Date reported:** 1994
Reference: De Vos 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax *(Bacillus anthracis)*$_{M,C}$ Rare occurrence				Spore ingestion, Insect vectors

Cape Mountain Zebra
Equus zebra zebra
Country and specific location: South Africa, Mountain Zebra National Park **Study period/Date reported:** 1970–1984 **Reference:** Penzhorn 1984

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Severe winter weather$_{N}$	N/A

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

A. MOUNTAIN ZEBRAS ... continued

E. z. zebra

Country and specific location: South Africa, Mountain Zebra National Park **Study period/Date reported:** 1972–1976 **Reference:** Bath 1979

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Nephritis (*Actinobacillus equuli*)$_{N,C}$				Direct contact with infected genital tracts of mares, N/V

E. z. zebra

Country and specific location: South Africa, Mountain Zebra National Park **Study period/Date reported:** 1973 **Reference:** Young *et al.* 1973

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
[B]African Horse Sickness (AHS)$_S$ [B]EHV-1$_S$			Babesiosis (*Babesia equi*)$_M$		AHS=*Culicoides imicola* EHV-1=Inhalation Babesiosis= *Rhipicephalus evertsi evertsi*

E. z. zebra

Country and specific location: South Africa, Mountain Zebra National Park **Study period/Date reported:** 1982 **Reference:** Barnard 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
EHV-1$_S$ Equine Encephalosis Virus (EEV)$_S$ Tested negative for AHS$_S$					EHV-1=Inhalation, Direct contact, N/V EEV=*Culicoides* vectors likely

E. z. zebra

Country and specific location: South Africa **Study period/Date reported:** 1991–1992 **Reference:** Barnard 1997

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative for AHS$_S$					AHS=*Culicoides imicola*

E. z. zebra

Country and specific location: South Africa, Mountain Zebra National Park **Study period/Date reported:** 1996 **Reference:** Barnard 1997

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative$_S$ for EEV and AHS					EEV=*Culicoides*, AHS=*Culicoides imicola*

B. GRÉVY'S ZEBRAS Continent of origin: Africa

Grévy's zebras
Equus grevyi

Country and specific location: East Africa **Study period/Date reported:** 1973 **Reference:** Pipano and Tadmor 1978

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Babesiosis (*Babesia equi*)$_M$		Tick vectors: *Rhipicephalus evertsi*

E. grevyi

Country and specific location: North-eastern Kenya **Study period/Date reported:** 1982 **Reference:** Ogaa 1983

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Capture-stress related abortion$_H$	N/A

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

C. PLAINS ZEBRAS Continent of origin: Africa

Plains zebras
[A]*Equus burchellii crawshayi*

Country and specific location: Zambia, Lumbwe Game Reserve **Study period/Date reported:** 1922 **Reference:** Tuchili *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$				Spore ingestion, Insect vectors

E. b. subspecies

Country and specific location: South Africa **Study period/Date reported:** 1928–1991 **Reference:** Swanepoel 1994b

Country and specific location: South Africa, Namibia **Study period/Date reported:** 1967–1976 **Reference:** Barnard 1979

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Rabies					Saliva infective, N/V Urban - dog Wildlife - mongoose

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1960 **Reference:** Pienaar 1961

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M}$				Spore ingestion, Insect vectors

[A]*E. b. antiquorum*

Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1960–1994 **Reference:** Gasaway *et al.* 1996

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Predation and Anthrax may limit population growth	Spore ingestion, Insect vectors

[A]*E. b. boehmi*

Country and specific location: Tanzania, Serengeti **Study period/Date reported:** 1961–1980 **Reference:** Sinclair and Norton-Griffiths 1982

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Predation or disease may regulate populations	N/R

E. b. subspecies

Country and specific location: Zimbabwe, Zambia, South Africa **Study period/Date reported:** 1963-1978 **Reference:** Hamblin and Hedger 1979

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative for BVD$_S$					N/V

E. b. subspecies

Country and specific location: Zimbabwe, South Africa, Zambia **Study period/Date reported:** 1963–1983 **Reference:** Al-Busaidy *et al.* 1987

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative for AKA$_S$					Insect vectors likely

[A]*E. b. boehmi*

Country and specific location: Northern Tanzania **Study period/Date reported:** 1964–1970 **Reference:** Kaliner *et al.* 1974

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Sarcocystosis (*Sarcocystis* spp.)$_P$		Sporocyst ingestion, Sporocyst dispersal by insects possible, NV

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

C. PLAINS ZEBRAS ... continued

[A]*E. b. antiquorum; E. b. crawshayi-E. b. chapmani* "hybrids"

Country and specific location: South Africa, Zimbabwe **Study period/Date reported:** 1964–1985 **Reference:** Shepherd *et al.* 1987

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
$CCHF_S$					Tick vectors of the genus *Hyalomma*

[A]*E. b. antiquorum*

Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1964–1992 **Reference:** Lindeque and Turnbull 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$ Blue wildebeest, elephant, springbok also affected				Spore ingestion, Insect vectors

[A]*E. b. boehmi*

Country and specific location: Tanzania, Kirawira **Study period/Date reported:** 1965–1968 **Reference:** Marek *et al.* 1973

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Tested negative for $Salmonella_C$				Oral route via feces, contaminated feed and water, N/V

[A]*E. b. crawshayi-E. b. chapmani* "hybrids"

Country and specific location: Zimbabwe **Study period/Date reported:** 1966–1972 **Reference:** Condy and Vickers 1972

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Brucellosis (*Brucella abortus*)$_S$				Oral route, inhalation, in utero, N/V

[A]*E. b. antiquorum*

Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1966–1974 **Reference:** Ebedes 1977

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_M$				Spore ingestion, Insect vectors

[A]*E. b. boehmi*

Country and specific location: Tanzania, Loliondo **Study period/Date reported:** 1968 **Reference:** Young and Purnell 1973

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Babesiosis (*Babesia equi*)$_M$		Tick vectors: *Rhipicephalus evertsi*

[A]*E. b. boehmi*

Country and specific location: Northern Tanzania and Kenya **Study period/Date reported:** 1971–1973 **Reference:** Kaliner *et al.* 1974

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Sarcocystosis (*Sarcocystis* spp.)$_P$		Sporocyst ingestion, Sporocyst dispersal by insects possible, NV

E. b. subspecies

Country and specific location: East Africa **Study period/Date reported:** 1973 **Reference:** Pipano and Tadmor 1978

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Babesiosis (*Babesia equi*)$_M$		Tick vectors: *Rhipicephalus evertsi*

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

C. PLAINS ZEBRAS ... continued

[A]*E. b. boehmi*

Country and specific location: Kenya **Study period/Date reported:** 1974 **Reference:** Davies and Lund 1974; Davies *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S					*Culicoides imicola* midge vector

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1975 **Reference:** Harthoorn and Young 1976

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Capture related pulmonary hypertension$_H$	N/A

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1975 **Reference:** Erasmus *et al.* 1978a

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Reovirus$_S$, (Type 3)					Arthropod vector

[A]*E. b. boehmi*

Country and specific location: Tanzania, Loliondo **Study period/Date reported:** 1975 **Reference:** Riemann *et al.* 1975

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Toxoplasmosis (*Toxoplasma gondii*)$_S$		Fecal contamination of feed and water by wild felids, N/V

[A]*E. b. antiquorum*

Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1975–1978 **Reference:** Berry 1981

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_M$			Predation$_H$	Spore ingestion, Insect vectors

[A]*E. b. antiquorum*

Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1975–1984; 1975–1990 **Reference:** Turnbull *et al.* 1986; Berry 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$				Spore ingestion, Insect vectors

[A]*E. b. boehmi*

Country and specific location: Northern Tanzania **Study period/Date reported:** 1977 **Reference:** Davies and Otieno 1977

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotype 1 Elephants tested positive for AHS_S					*Culicoides imicola* midge vector

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1979 **Reference:** Erasmus *et al.* 1978b, 1979

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotype 3					*Culicoides imicola* midge vector

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

C. PLAINS ZEBRAS ... continued

[A]*E. b. boehmi*

Country and specific location: Kenya **Study period/Date reported:** 1981 **Reference:** Nyaga et al. 1981

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative for $PI\text{-}3_S$					Aerosol, N/V

[A]*E. b. antiquorum*

Country and specific location: Namibia **Study period/Date reported:** 1983 **Reference:** Daly *et al.* 1983

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Sarcocystosis (*Sarcocystis* spp.)$_P$		Sporocyst ingestion, Sporocyst dispersal by insects possible, NV

[A]*E. b. boehmi*

Country and specific location: Kenya, Semi-arid zones **Study period/Date reported:** 1984 **Reference:** Davies and Jessett 1985

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AKA_S					Insect vectors likely

[A]*E. b. antiquorum*

Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1984–1987 **Reference:** Turnbull *et al.* 1989

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$ (Also high prevalence in carnivores)				Spore ingestion, Insect vectors

[A]*E. b. crawshayi*

Country and specific location: Zambia, Luangwa Valley **Study period/Date reported:** 1987 **Reference:** Mulla and Rickman 1988

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Trypanosomiasis (*Trypanosoma brucei rhodesiense*)$_M$		Tsetse fly vector, Zebra can be a natural host for human Trypanosomiasis

[A]*E. b. crawshayi*

Country and specific location: Zambia, South Luangwa National Park **Study period/Date reported:** 1987–1991 **Reference:** Tuchili *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C,S}$				Spore ingestion, Insect vectors

[A]*E. b. boehmi*

Country and specific location: Tanzania, Tarangire National Park **Study period/Date reported:** 1988 **Reference:** Mbise *et al.* 1991

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$				Spore ingestion, Insect vectors

[A]*E. b. boehmi*

Country and specific location: Tanzania **Study period/Date reported:** 1989 **Reference:** Hamblin *et al.* 1990

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotypes 1–9; Tested negative$_S$ for FMD, BHV-1, BHV-2, LSD, AKA, BEF, BT					AHS=*Culicoides imicola;* Ruminant viruses

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

C. PLAINS ZEBRAS ... continued

E. b. subspecies

Country and specific location: South Africa, Namibia **Study period/Date reported:** 1990 **Reference:** Coetzer and Erasmus 1994b

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
EEV_S (Bryantson, Kyalami Serotypes)					*Culicoides* vectors likely

[A]*E. b. antiquorum*

Country and specific location: Namibia, Etosha National Park **Study period/Date reported:** 1991 **Reference:** Turnbull *et al.* 1992

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Tested negative for Anthrax toxin components	(*Bacillus anthracis*)$_S$			Spore ingestion, Insect vectors

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1991–1992 **Reference:** Barnard and Paweska 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
EEV_S, Serotypes 1–7 $EHV\text{-}1_S$, $EHV\text{-}4_S$ Tested negative$_S$ for EI, EAV					EEV=*Culicoides* EHV=Inhalation, Direct contact, N/V

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1991–1992; 1994

Reference: Barnard 1993; Lord *et al.* 1997; Barnard *et al.* 1994a

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
$AHS_{S'V}$ Serotypes 1–9					*Culicoides imicola* midge vector

[A]*E. b. boehmi*

Country and specific location: Kenya, Nairobi **Study period/Date reported:** 1992 **Reference:** Binepal *et al.* 1992

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotypes 1–9					*Culicoides imicola* midge vector

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1992 **Reference:** Barnard *et al.* 1995

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotypes 1–9 (Low level antibodies against AHS also found in elephants)					*Culicoides imicola* midge vector

[A]*E. b. antiquorum-E. b. chapmani* "hybrids"

Country and specific location: Botswana, Chobe ecosystem **Study period/Date reported:** 1992–1994

Reference: Barnard 1997; Osofsky, pers. comm., 1997

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotypes 1–9 $EHV\text{-}1_S$, EEV_S, WSL_S, AKA_S Tested negative$_S$ for EI, EIA, EAV and BHV-1, BHV-2, MCF, PI-3, LSD, BEF, BT, RVF					AHS=*Culicoides imicola* EHV-1=Inhalation EEV=*Culicoides* WSL=Mosquitoes AKA=Insect vectors

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

C. PLAINS ZEBRAS ... continued

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1993 **Reference:** Williams *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S EEV_S					AHS=*Culicoides imicola* EEV=*Culicoides* likely

Zebra (*E. b.* subspecies likely)

Country and specific location: South Africa, Kenya, Zimbabwe, Botswana **Study period/Date reported:** 1993 **Reference:** Paweska *et al.* 1997

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative for EAV_S (Horses, donkeys, mules positive for EAV_S)					Aerosol, fomites, N/V

[A]*E. b. antiquorum*

Country and specific location: South Africa (Ecosystem zones: Woodland; Forest transition; Semi-desert; Cape scrubland)

Study period/Date reported: 1993–1995 **Reference:** Barnard 1997

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotypes present varied with ecosystems; EHV-1_S, EEV_S all zones; WSL_S, AKA_S zones N/R; Tested negative$_S$ for EI, EIA, EAV and BHV-1, BHV-2, MCF, PI-3, LSD, BEF, BT, RVF					AHS=*Culicoides imicola*; EHV-1=Inhalation EEV=*Culicoides* WSL=Mosquitoes AKA=Insect vectors EI/EAV=Aerosol, fomites EIA=Insect vectors

E. b. subspecies

Country and specific location: South Africa **Study period/Date reported:** 1994 **Reference:** Barnard *et al.* 1994b

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative for WD MCF	$(AHV\text{-}1)_S$				Aerosol, ?Vectors

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park (KNP); Namibia, Etosha National Park (ENP) **Study period/Date reported:** 1994 **Reference:** De Vos 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Anthrax (*Bacillus anthracis*)$_{M,C}$ KNP-Epizootic ENP-Sporadic				Spore ingestion, Insect vectors

E. b. subspecies

Country and specific location: Africa (southern) **Study period/Date reported:** 1994 **Reference:** Bigalke 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Brucellosis (*Brucella abortus, Brucella melitensis*)$_S$				Oral route, Inhalation, In utero, N/V

E. b. antiquorum

Country and specific location: South Africa **Study period/Date reported:** 1994 **Reference:** Bigalke and Prozesky 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Besnoitiosis (*Besnoitia bennetti*)$_M$		?Vectors Transmission unknown

Table 12.1 ... continued. Reported diseases of free-ranging wild equids.

C. PLAINS ZEBRAS ... continued

Zebra (*E. b.* subspecies likely)

Country and specific location: West, Central and East Africa **Study period/Date reported:** 1994 **Reference:** Bigalke 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Trypanosomiasis (*Trypanosoma* spp.)$_{M}$		Tsetse fly vectors

D. PRZEWALSKI'S HORSES Continent of origin: Asia (Extirpated in the wild, currently being reintroduced)

Przewalski's horse

Equus ferus przewalskii

Country and specific location: Mongolia (SW), Tachin Tal **Study period/Date reported:** 1999–2000 **Reference:** Walzer *et al.* 2000; Walzer, pers. comm. 2001; Stuewe, pers. comm. 2001

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Possible strangles (*Streptococcus equi*)		Babesiosis (*Babesia caballi*)$_{P,S}$ *Babesia equi*)$_{P,S}$		Babesia: Tick vectors: *Dermacentor nutalli*

E. ASIATIC AND AFRICAN WILD ASSES

Asiatic wild asses **Continent of origin: Asia**

Equus hemionus subspecies (*E. h. hemionus, E. h. luteus, E. h. kulan, E. h. onager, E. h. khur*)

E. h. khur

Country and specific location: India **Study period/Date reported:** 1959 **Reference:** Caughley and Gunn 1996

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
			Surra (*Trypanosoma evansi*)$_{M}$		Biting flies (Horseflies)

E. h. khur

Country and specific location: India **Study period/Date reported:** 1960 **Reference:** Caughley and Gunn 1996

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS$_{S}$					*Culicoides* spp. midge vector

Equus kiang subspecies (*E. k. kiang, E. k. holdereri, E. k. polyodon*)

Information lacking

African wild asses **Continent of origin: Africa**

Equus africanus

Information lacking

Key to disease diagnosis:

Diagnostic test:

C= Culture Results
N= Gross Necropsy Results
M= Microscopic Exam of Blood Smears
S= Serology
V= Virus Isolation
H= History and Clinical Signs
P= Histopathology
E= Exploratory Surgery

[A] Equid subspecies surmised from Duncan (1992), based on country and specific location reported.
[B] Results not conclusive

Reported vector:

? Vectors= Vectors Unknown
N/V= No Vector
N/A= Not Applicable
N/R= Not Reported

The ruminant diseases listed above have been included because these infectious agents have been tested for in some equid populations.
The significance of positive test results is generally unknown.

1° Equine viral diseases:

AHS= African horse sickness
EEV= Equine Encephalosis Virus
EHV= Equine Herpesvirus
EI= Equine Influenza
EIA= Equine Infectious Anemia
EAV= Equine Arteritis Virus

1° Ruminant viral diseases:

AKA= Akabane Disease
BHV-1= Bovine Herpesvirus 1
BHV-2= Bovine Herpesvirus 2
BEF= Bovine Ephemeral Fever
BT= Bluetongue
RVF= Rift Valley Fever (zoonotic)
LSD= Lumpy Skin Disease
WD MCF= Wildebeest Derived
Malignant Catarrhal Fever
AHV-1= Alcelaphine Herpesvirus 1 (same as WD MCF)
WSL= Wesselsbron Disease
FMD= Foot and Mouth Disease
PI-3= Parainfluenza
BVD= Bovine Viral Diarrhea

1° Human viral diseases:

CCHF= Crimean-Congo Hemorrhagic Fever Virus (zoonotic)

Table 12.2. Reported diseases of captive wild equids.

A. MOUNTAIN ZEBRAS Continent of origin: Africa

Hartmann's mountain zebra
[A]*Equus zebra hartmannae*
Country and specific location: England, London Zoo **Study period/Date reported:** 1956-1976 **Reference:** Jones 1976
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Colic, Respiratory and Metabolic diseases, Capture myopathy, Abortion$_N$	N/R

E. z. hartmannae
Country and specific location: California, San Diego Zoo and Wild Animal Park **Study period/Date reported:** 1964-1977 **Reference:** Griner 1978
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Capture myopathy$_N$	N/A

E. z. hartmannae
Country and specific location: Wisconsin, Vilas Park Zoo **Study period/Date reported:** 1973 **Reference:** Decker *et al.* 1975
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Enterolithiasis$_N$	N/V

E. z. hartmannae
Country and specific location: Czechoslovakia, Zoo of Dvur Kralove **Study period/Date reported:** 1980 **Reference:** Mikulicova and Mikulica 1981
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Listeriosis (*Listeria monocytogenes*)$_S$				Contaminated feed and water, N/V

[A]*E. z. hartmannae*
Country and specific location: Guwahati, Assam State Zoo **Study period/Date reported:** 1985-1989 **Reference:** Chakraborty and Chaudhury 1993
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Bacterial Pseudomycosis (*Staphlyococcus aureus*)$_C$				Wound infections, N/V

[A]*E. z. hartmannae*
Country and specific location: Guwahati, Assam State Zoo **Study period/Date reported:** 1988-1991 **Reference:** Chakraborty and Sarma 1995
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Enteritis (*Escherichia coli*)$_C$				Fecal-oral route, N/V

B. GRÉVY'S ZEBRAS Continent of origin: Africa

Grévy's zebras
Equus grevyi
Country and specific location: England, London Zoo **Study period/Date reported:** 1956-1976 **Reference:** Jones 1976
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Injury, Colic, Respiratory and Metabolic diseases, Capture myopathy$_N$	N/R

E. grevyi
Country and specific location: California, San Diego Zoo and Wild Animal Park **Study period/Date reported:** 1964-1977 **Reference:** Griner 1978
Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Capture myopathy$_N$	N/A

Table 12.2 ... continued. Reported diseases of captive wild equids.

B. GRÉVY'S ZEBRAS ... continued

E. grevyi

Country and specific location: Germany, Leipzig Zoo **Study period/Date reported:** 1974 **Reference:** Eulenberger *et al.* 1975

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Capture myopathy$_{P}$	N/A

E. grevyi

Country and specific location: Czechoslovakia, Zoo of Dvur Kralove **Study period/Date reported:** 1978 **Reference:** Koci 1982

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				White muscle disease$_{N,P}$	N/A

E. grevyi

Country and specific location: Ontario, Canada, Metropolitan Toronto Zoo **Study period/Date reported:** 1978-1979 **Reference:** Petric *et al.* 1981

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Rotavirus$_{S}$					Fecal-oral route, N/V

E. grevyi

Country and specific location: Czechoslovakia, Zoo of Dvur Kralove **Study period/Date reported:** 1979-1980 **Reference:** Mikulicova and Mikulica 1981

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Listeriosis (*Listeria monocytogenes*)$_{C,S}$				Contaminated feed and water, N/V

E. grevyi

Country and specific location: Czechoslovakia, Zoo of Dvur Kralove **Study period/Date reported:** 1981 **Reference:** Mikulicova *et al.* 1982

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Septicemia and Pneumonia (*Klebsiella pneumoniae*)$_{N,P}$				Mares-Venereal Foals-In utero, N/V

E. grevyi

Country and specific location: Illinois, Lincoln Park Zoo **Study period/Date reported:** 1984 **Reference:** Wolff *et al.* 1986

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Herpes virus infection and abortion (EHV-1)$_{H,N,V}$					Virus inhalation, Direct contact, N/V

E. grevyi

Country and specific location: Georgia, Atlanta Zoo **Study period/Date reported:** 1991 **Reference:** Dillehay and Silberman 1991

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
		Systemic Phaeohyphomycosis$_{M}$			Fungus inhalation, Direct contact, N/V

C. PLAINS ZEBRAS Continent of origin: Africa

Plains zebras
Equus burchellii subspecies

Country and specific location: England, London Zoo **Study period/Date reported:** 1956-1976 **Reference:** Jones 1976

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Injury, Metabolic and Respiratory diseases, Colic, Abortion, Dystocia$_{N}$	N/R

Table 12.2 ... continued. Reported diseases of captive wild equids.

C. PLAINS ZEBRAS ... continued

E. b. boehmi

Country and specific location: Washington, D.C., National Zoo **Study period/Date reported:** 1961-1971 **Reference:** Montali *et al.* 1974

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Neurologic disease: Degenerative Myelopathy$_{P}$	N/V

E. b. boehmi

Country and specific location: California, San Diego Zoo and Wild Animal Park **Study period/Date reported:** 1964-1977 **Reference:** Griner 1978

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Capture Myopathy$_{N}$	N/A

E. b. boehmi

Country and specific location: Canada, Ontario **Study period/Date reported:** 1972 **Reference:** Higginson *et al.* 1973

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				White Muscle Disease$_{P}$	N/A

E. b. boehmi

Country and specific location: Germany, Leipzig Zoo **Study period/Date reported:** 1974 **Reference:** Eulenberger *et al.* 1975

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Capture Myopathy$_{P}$	N/A

E. b. subspecies

Country and specific location: New Jersey **Study period/Date reported:** 1974 **Reference:** Mayhew *et al.* 1977

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Neurological disease: Degenerative Myeloencephalopathy$_{P}$	N/V

[A]*E. b. antiquorum*

Country and specific location: South Africa, Kruger National Park **Study period/Date reported:** 1975 **Reference:** Erasmus *et al.* 1978a

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Reovirus$_{S}$ (Type 2)					Arthropod vector

E. b. antiquorum

Country and specific location: Germany, West Berlin Zoo **Study period/Date reported:** 1975-1976 **Reference:** Goltenboth and Klos 1989

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Neurologic disease: Degenerative Myeloencephalopathy$_{P}$ and Vitamin E deficiency$_{S}$	N/V

E. b. antiquorum; E. b. boehmi

Country and specific location: Germany, Berlin Zoo **Study period/Date reported:** 1975-1986 **Reference:** Kahrmann *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
EHV-1$_{P,H}$ (Neurologic form)					Virus inhalation, Direct contact, N/V

Table 12.2 ... continued. Reported diseases of captive wild equids.

C. PLAINS ZEBRAS ... continued

E. b. subspecies

Country and specific location: England, Whipsnade Park **Study period/Date reported:** 1976 **Reference:** Ashton *et al.* 1977

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Equine Grass Sickness$_{P}$	Etiology unknown

E. b. boehmi

Country and specific location: Alabama, Auburn **Study period/Date reported:** 1976 **Reference:** Higgins *et al.* 1977

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Neurologic disease: Neurofibrillary accumulation and degeneration$_{P}$	N/V

E. b. subspecies

Country and specific location: Nigeria, Kano Zoo **Study period/Date reported:** 1978 **Reference:** Okoh 1980

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Pasteurellosis (*Pasteurella multocida*)$_{N,C}$				Stress related, N/V

E. b. boehmi; E. b. antiquorum

Country and specific location: Ontario, Canada, Metropolitan Toronto Zoo **Study period/Date reported:** 1978-1979 **Reference:** Petric *et al.* 1981

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Rotavirus$_{S}$					Fecal-oral route, N/V

E. b. boehmi; E. b. antiquorum

Country and specific location: Czechoslovakia, Zoo of Dvur Kralove **Study period/Date reported:** 1980 **Reference:** Mikulicova and Mikulica 1981

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Listeriosis (*Listeria monocytogenes*)$_{S}$				Contaminated feed and water, N/V

E. b. boehmi

Country and specific location: Japan, Obihiro Zoo **Study period/Date reported:** 1981 **Reference:** Taniyama *et al.* 1985

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Ovarian Papillary Cystadenocarcinoma$_{N,P}$	N/V

E. b. subspecies

Country and specific location: Washington, D.C., National Zoo **Study period/Date reported:** 1984 **Reference:** Montali *et al.* 1984, 1985

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Herpes virus myelitis (EHV-1)$_{S,H}$					Virus inhalation, Direct contact, N/V

E. b. boehmi

Country and specific location: Ohio, Columbus Zoo **Study period/Date reported:** 1986 **Reference:** Gardner *et al.* 1986

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Colic: Large Colon Volvulus$_{E}$	N/A

Table 12.2 ... continued. Reported diseases of captive wild equids.

C. PLAINS ZEBRAS ... continued

E. b. subspecies

Country and specific location: Spain, Madrid (Movement in 1987 from Namibia) **Study period/Date reported:** 1987 **Reference:** Rodriguez *et al.* 1992a, 1992b

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
AHS_S, Serotype 4					*Culicoides imicola* midge vector

E. b. chapmani

Country and specific location: Czechoslovakia, Zoo of Liberec **Study period/Date reported:** 1988 **Reference:** Jurek 1989

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Uterine Torsion and $Prolapse_H$	N/A

E. b. boehmi

Country and specific location: California, Oakland Zoo **Study period/Date reported:** 1991-1992 **Reference:** McDuffee *et al.* 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Colic: $Enterolithiasis_E$	N/A

Zebra (*E. b.* subspecies likely)

Country and specific location: Zoos: USA, Canada, Australia, Netherlands, Germany **Study period/Date reported:** 1993 **Reference:** Paweska *et al.* 1997

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Tested negative for EAV_S (Horses, donkeys, mules tested positive for EAV_S)					Aerosol, fomites, N/V

Zebra (*E. b.* subspecies likely)

Country and specific location: Switzerland **Study period/Date reported:** 1994 **Reference:** Weiss *et al.* 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
EAV_S					Aerosol, fomites, N/V

E. b. subspecies

Country and specific location: Tennessee, Knoxville Zoo **Study period/Date reported:** 1994 **Reference:** Kennedy *et al.* 1996

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Zebra EHV-1_S positive; Nearby Thomson's Gazelle with encephalitis tested EHV-$1_{S,V}$ positive					Virus inhalation, Direct contact, N/V

D. PRZEWALSKI'S HORSES Continent of origin: Asia

Przewalski's horse
Equus ferus przewalskii

Country and specific location: England, London Zoo **Study period/Date reported:** 1956-1976 **Reference:** Jones 1976

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Injury, Hereditary condition, Capture myopathy, $Abortion_N$	N/R

E. f. przewalskii

Country and specific location: Germany, West Berlin Zoo **Study period/Date reported:** 1975-1976 **Reference:** Goltenboth and Klos 1989

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Degenerative $myeloencephalopathy_P$ and Vitamin E $deficiency_S$	N/V

Table 12.2 ... continued. Reported diseases of captive wild equids.

D. PRZEWALSKI'S HORSES ... continued

E. f. przewalskii

Country and specific location: Germany, Berlin Zoo **Study period/Date reported:** 1976-1985 **Reference:** Kahrmann *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Neurologic disease (EHV-1)$_{P,H}$					Virus inhalation, Direct contact, N/V

E. f. przewalskii

Country and specific location: England, Whipsnade Park **Study period/Date reported:** 1976 **Reference:** Ashton *et al.* 1977

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Equine grass sickness$_{P}$	Etiology unknown

E. f. przewalskii

Country and specific location: New York **Study period/Date reported:** 1977-1983 **Reference:** Liu *et al.* 1983

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Degenerative myelopathy$_{P}$ and Vitamin E deficiency$_{S}$	N/V

E. f. przewalskii

Country and specific location: NR **Study period/Date reported:** 1978 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Wobbler (Cervical vertebral malformation)	N/A

E. f. przewalskii

Country and specific location: Germany, Leipzig Zoo **Study period/Date reported:** 1979 **Reference:** Elze and Eulenberger 1980

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Abortion, Septicemia: *Streptococcus* spp.				Oral, Respiratory, Wounds, Umbilicus, N/V

E. f. przewalskii

Country and specific location: England, London Zoo **Study period/Date reported:** 1980 **Reference:** Liu *et al.* 1983

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Degenerative myeloencephalopathy$_{P}$	N/V

E. f. przewalskii

Country and specific location: Colorado, Denver Zoo **Study period/Date reported:** 1980 **Reference:** Cambre 1986

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Abortion and Uterine prolapse$_{H}$	N/R

E. f. przewalskii

Country and specific location: NR **Study period/Date reported:** 1980 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Bronchopneumonia (*Pseudomonas*)$_{N}$				Contaminated feed, Aerosol, N/V

Table 12.2 ... continued. Reported diseases of captive wild equids.

D. PRZEWALSKI'S HORSES ... continued

E. f. przewalskii

Country and specific location: NR **Study period/Date reported:** 1980-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Abortion, Stillbirth (EHV-1)	Stillbirth: *Aeromonas, Enterobacteria, Streptococcus* spp.			Abortion, Stillbirth: Enteritis, Stress, Twinning, Cleft Palate, Vitamin E deficiency	N/R

E. f. przewalskii

Country and specific location: New York **Study period/Date reported:** 1981 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Equine degenerative myelopathy $(EDM)_p$	N/V

E. f. przewalskii

Country and specific location: NR **Study period/Date reported:** 1981-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Equine Influenza (EI)					Aerosol, fomites, N/V

E. f. przewalskii

Country and specific location: NR **Study period/Date reported:** 1981-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Equine Rhinopneumonitis (EHV-1)					Virus inhalation, Direct contact, N/V

E. f. przewalskii

Country and specific location: Europe **Study period/Date reported:** 1981-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
	Tetanus (*Clostridium tetani*)				*Clostridium tetani* spores in wound, N/V

E. f. przewalskii

Country and specific location: 5 Zoos **Study period/Date reported:** 1981-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Injury (Trauma, Fractures)	N/A

E. f. przewalskii

Country and specific location: 6 Zoos **Study period/Date reported:** 1981-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Neonatal deaths: Septicemia, Hypothermia from severe weather, Pneumonia, Enteritis, Stillbirth, Vitamin E deficiency, Injury from other horses	N/R

E. f. przewalskii

Country and specific location: Germany; New York **Study period/Date reported:** 1981-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Euthanasia for Geriatric problems	N/A

Table 12.2 ... continued. Reported diseases of captive wild equids.

D. PRZEWALSKI'S HORSES ... continued

E. f. przewalskii

Country and specific location: California, San Diego Wild Animal Park **Study period/Date reported:** 1982-1983 **Reference:** Ryder and Massena 1988

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Male Infanticide$_{H,N}$	N/A

E. f. przewalskii

Country and specific location: Washington, D.C., National Zoo **Study period/Date reported:** 1982-1984 **Reference:** Montali *et al.* 1985

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Herpes virus infection (EHV-1)$_S$					Virus inhalation, Direct contact, N/V

E. f. przewalskii

Country and specific location: Minnesota Zoo; New York **Study period/Date reported:** 1982-1989 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Colic: Intussusception, Torsion, Volvulus$_N$	N/A

E. f. przewalskii

Country and specific location: NR **Study period/Date reported:** 1986 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Meningoencephalitis, Enterocolitis$_N$	N/R

E. f. przewalskii

Country and specific location: California; New York **Study period/Date reported:** 1986-1988 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Laminitis	N/A

E. f. przewalskii

Country and specific location: California **Study period/Date reported:** 1987-1988 **Reference:** Houpt 1994

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
		Coccidiomycosis *(Coccidiodes immitis)*$_N$			Inhalation of fungal spores, N/V

E. f. przewalskii

Country and specific location: NR **Study period/Date reported:** 1993 **Reference:** Anderson *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Degenerative joint disease$_N$, Subclinical lumbar polyradiculopathy$_P$	N/A

E. ASIATIC AND AFRICAN WILD ASSES

Asiatic wild asses **Continent of origin: Asia**

Equus hemionus subspecies (*E. h. hemionus, E. h. luteus, E. h. kulan, E. h. onager, E. h. khur*)

E. h. onager

Country and specific location: England, London Zoo **Study period/Date reported:** 1956-1976 **Reference:** Jones 1976

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				Injury, Colic, Respiratory disease, Capture myopathy, Septicemia$_N$	N/R

Table 12.2 ... continued. Reported diseases of captive wild equids.

E. ASIATIC AND AFRICAN WILD ASSES ... continued

E. h. subspecies

Country and specific location: NR **Study period/Date reported:** 1972 **Reference:** Pohle 1978

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				$Trauma_H$ (Primary cause of mortality reported from international zoos)	N/A

E. h. onager

Country and specific location: Germany, Berlin Zoo **Study period/Date reported:** 1981 **Reference:** Kahrmann *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Neurologic disease: $EHV\text{-}1_{P,H}$					Virus inhalation, Direct contact, N/V

E. h. onager

Country and specific location: Washington, D.C., National Zoo **Study period/Date reported:** 1984 **Reference:** Montali *et al.* 1985

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
Abortion: $EHV\text{-}1_{V,S}$					Virus inhalation, Direct contact, N/V

E. h. onager

Country and specific location: NR **Study period/Date reported:** 1993 **Reference:** Anderson *et al.* 1993

Reported Diseases/Conditions, Vectors and Transmission

Viral	Bacterial	Fungal	Protozoal	Other diseases or conditions	Disease transmission and vector reported
				$Trauma_N$, Subclinical lumbar $polyradiculopathy_P$	N/A

Equus kiang subspecies (*E. k. kiang, E. k. holdereri, E. k. polyodon*)
Information Lacking

African wild asses **Continent of origin: Africa**

Equus africanus
Information lacking

Key to disease diagnosis:
Diagnostic test:
C= Culture Results
N= Gross Necropsy Results
M= Microscopic Exam of Blood Smears
S= Serology
V= Virus Isolation
H= History and Clinical Signs
P= Histopathology
E= Exploratory Surgery

[A] Equid subspecies surmised from Duncan (1992), based on country and specific location reported.
[B] Results not conclusive

Reported vector:
? Vectors= Vectors Unknown
N/V= No Vector
N/A= Not Applicable
N/R= Not Reported

The ruminant diseases listed above have been included because these infectious agents have been tested for in some equid populations. The significance of positive test results is generally unknown.

1° Equine viral diseases:
AHS= African horse sickness
EEV= Equine Encephalosis Virus
EHV= Equine Herpesvirus
EI= Equine Influenza
EIA= Equine Infectious Anemia
EAV= Equine Arteritis Virus

1° Ruminant viral diseases:
AKA= Akabane Disease
BHV-1= Bovine Herpesvirus 1
BHV-2= Bovine Herpesvirus 2
BEF= Bovine Ephemeral Fever
BT= Bluetongue
RVF= Rift Valley Fever (zoonotic)
LSD= Lumpy Skin Disease
WD MCF= Wildebeest Derived
Malignant Catarrhal Fever
AHV-1= Alcelaphine Herpesvirus 1 (same as WD MCF)
WSL= Wesselsbron Disease
FMD= Foot and Mouth Disease
PI-3= Parainfluenza
BVD= Bovine Viral Diarrhea

1° Human viral diseases:
CCHF= Crimean-Congo Hemorrhagic Fever Virus (zoonotic)

on the diseases affecting wild equids is also provided. In addition, selected references regarding equine medicine, surgery, and reproduction can be found in Appendix 4. Local and/or regional veterinary authorities, the Office International des Epizooties (OIE), as well as the IUCN Species Survival Commission (SSC) Veterinary Specialist Group (VSG) and the Reintroduction Specialist Group (RSG) should be consulted when specific veterinary questions arise during project design, implementation, or monitoring.

12.2 Wild populations and disease

The fundamental strategy for single-species conservation involves reducing a population's risk of going extinct while minimising the population's loss of genetic diversity. Loss of genetic variation may result in decreased resistance to disease. Disease is one contributor to the financial, genetic, and demographic risks facing conservation programs, and must be considered when conservation strategies are developed (Ballou 1993). Population viability analysis, a form of modelling that assesses the probability of extinction and the loss of genetic diversity over time, can be used to evaluate risks facing small populations. Models can be used to evaluate ecological processes and to assess these risks – including those risks related to infectious disease. Note that the IUCN SSC Conservation Breeding Specialist Group (CBSG) has been investigating novel options for disease risk assessment (Armstrong and Seal 2000). The most important and catastrophic disease risks are epizootics, which can result from the transmission of local agents or from the introduction of novel or emergent diseases (Ballou 1993; Daszak *et al.* 2000). Epizootics and other disease occurrences can affect the long-term viability of a population by reducing survival and reproduction, and/or by increasing susceptibility to predators and various forms of stress (Ballou 1993).

Lyles and Dobson (1993) stressed the importance of host-parasite relationships in the management of wildlife populations:

> "Outbreaks of infectious diseases can ruin conservation programs. Biologically diverse parasites will never be entirely eliminated from intensively managed wildlife. Rather, one of the great challenges facing conservation biologists is to learn how to manage the natural and healthy relationship between parasites and their hosts."

Thus, one must also recognise the value of conserving biodiverse equine-specific parasites. To conserve the remaining equids, their genetic diversity, and their relationship with the diverse array of parasites with which they have evolved, two new approaches offer promise. One involves developing economic, social, and political linkages that encourage local people to participate in and benefit from the conservation of wildlife (Duncan 1992; Osofsky 1997). The second encompasses managing fragmented populations of equids using modern genetic and demographic principles (Duncan 1992). Metapopulation management, where subpopulations exist in geographically distinct areas yet are managed via exchange of individuals, will likely become a critical strategy for wild equid conservation. These subpopulations are managed together as one large genetic unit, thus maintaining genetic diversity (Ballou 1993). However, these subpopulations may be very different with regard to disease epidemiology and must be managed accordingly. The benefits, thus, have potential costs: the translocation of animals increases the risks of moving diseases among populations. Yet, with a thorough knowledge of disease epidemiology and control, these risks are potentially manageable (Ballou 1993).

12.3 Management implications

12.3.1 Disease testing considerations

Diagnostic testing plays an important role in monitoring the health of captive and free-ranging wildlife populations (Gardner *et al.* 1996). For wild species, a variety of tests is used to identify the agent(s) involved in disease in individuals and populations, as well as to detect exposure to agent(s). Such tests are critical epidemiological tools, providing information on the prevalence of disease, the status of infections in populations, risk factors for disease, and the probability of disease transmission between wildlife and domestic species, as well as between wildlife and humans (Gardner *et al.* 1996).

Serological testing (the measurement of serum antibody against microorganisms) is the most frequently used diagnostic test in wildlife. Serology allows for discrimination between exposed and non-exposed animals, and sometimes for differentiation between actual infection, resolved infection, and vaccine-induced seroconversion (Worley 1993). Several serological tests are available to detect antibodies to African horse sickness (AHS), for example. Serogroup-specific tests for AHS virus isolates include complement fixation (CF), agar-gel immunodiffusion (AGID), direct or indirect immunofluorescence (IFA), and enzyme-linked immunosorbent assay (ELISA), while specific serotypes are identified by virus neutralisation (VN) (Williams *et al.* 1993; Coetzer and Erasmus 1994a). ELISA tests have been developed, for example, to selectively differentiate between two orbiviruses (AHS and equine encephalosis (EEV) viruses) that infect equids (Williams *et al.* 1993). In addition, the ELISA test (as a quantitative serological tool for the detection of antibodies against AHS) has been shown to be superior to the CF test with regards to sensitivity and specificity (Williams 1987). Most serologic tests used in wildlife species have been directly transposed, without validation, from use in domestic species. These tests may not perform identically in wildlife (Gardner *et al.* 1996). Note that most tests do not provide 100% accuracy for disease diagnosis, and thus test interpretation requires knowledge of assay sensitivity and specificity. For many serologic tests, such information is lacking in wildlife veterinary medicine. This information would improve estimates of disease prevalence, would help in assessing the risk of disease transmission, and would

facilitate management decisions regarding animal translocations (Gardner *et al.* 1996).

Isolating pathogens is essential to understanding them. Culture techniques utilising selective media have proven very successful for the detection of most bacterial and fungal organisms in domestic and wild animals (Worley 1993). New advances in molecular biology have led to the development of new diagnostic tests, such as the polymerase chain reaction (PCR), which utilises DNA probes for the rapid detection and identification of infectious agents directly from clinical specimens (Worley 1993; Coetzer and Erasmus 1994a). DNA probes may be the only diagnostic method of detection for viruses that replicate slowly, establish persistent infections, express low levels of antigen, or incorporate into the host genome (Worley 1993).

12.3.2 Disease control recommendations

In this section, we focus on southern Africa for illustrative purposes. Animal disease research in this region has been relatively comprehensive. We use diseases such as African horse sickness and anthrax to illustrate some of the basic epidemiological principles of importance to wildlife managers around the world. These principles are particularly important as pressures at the wildlife/livestock interface continue to balloon.

The control of infectious diseases is based upon an understanding of disease epidemiology (Swanepoel 1994a). Information on disease distribution, hosts, vectors, modes of transmission, carrier states, and pathogenicity is essential for the design, implementation, and monitoring of conservation plans (Swanepoel 1994a). The wild species of southern Africa, for example, have been adapting over millions of years to their environments and to the myriad of infectious agents and parasites of this region. As such, they have acquired natural resistance to these indigenous diseases and often serve as carriers of disease or as readily available maintenance hosts (Bigalke 1994).

Vectors play a key role in the spread and maintenance of many diseases affecting domestic and wildlife species in southern Africa and elsewhere (Norval 1994; Phelps and Lovemore 1994; Nevill 1994; Nevill *et al.* 1994; Meiswinkel *et al.* 1994; Jupp 1994; Bengis 2002a; Bengis 2002b). The control of arthropod-born viruses (arboviruses), such as AHS, may be directed at the susceptible vertebrate species, the vertebrates that serve as maintenance or intermediate hosts of the virus, and the arthropod vectors (Swanepoel 1994a). As presented in tables 12.1 and 12.2, *Culicoides* midge vectors are important in the transmission of AHS and EEV viruses in equids, for example. The eradication of many vectors, including *Culicoides*, is impossible because adults occur in large numbers and their larval habitats are widespread (Meiswinkel *et al.* 1994). Thus, disease prevention is directed at lowering the chances of domestic animals becoming infected. Such methods include vaccination of domestic equids at an early age to induce herd immunity, stabling of susceptible animals at night when *Culicoides* species are most active, and avoidance of moist, low-lying areas during times of peak midge activity (Meiswinkel *et al.* 1994).

Other vectors of concern for domestic equids in southern Africa include, for example, ticks (e.g. babesiosis), tsetse flies (trypanosomiasis), and tabanid flies (e.g. equine infectious anaemia, anthrax). Acaricides and vaccines can be used in the control of ticks and tick-borne diseases (Norval 1994). In general, trypanosomiasis control includes vector control or elimination, the use of trypanotolerant livestock, and administration of curative and prophylactic drugs (Phelps and Lovemore 1994). Tabanid control encompasses the use of insect traps or insecticide treatment of animals (Nevill *et al.* 1994). Control of vectors has historically involved selective clearing and drainage of land to reduce survival of hematophagous arthropods (Swanepoel 1994a). In addition, larvicidal treatments have been applied to water where vectors breed. The measures outlined above come from literature describing efforts to control disease in domestic animals. We do not necessarily endorse particular methods in this chapter, and recognise that most wild animals have adapted to living with native parasites. Particularly when the widespread use of insecticides is being considered, environmental consequences should be carefully assessed beforehand, with a "first, do no harm" perspective taken in regards to ecosystem health.

The most practical method for controlling many diseases in domestic and wildlife species, especially diseases caused by arboviruses, is the protection of susceptible vertebrate species through vaccination (Swanepoel 1994a). Vaccines are designed to protect susceptible animals against infectious diseases by stimulating immune responses. Viral vaccines are generally more effective than bacterin or anti-parasite vaccines because the proteins used are smaller. Herd immunity is the immunologically-derived resistance of a population to an infectious agent, either from natural infection or immunisation (Van Dijk *et al.* 1994). Mathematical modelling can be used to determine the level of herd immunity required in a population depending on the primary objective (e.g. protecting individuals, controlling diseases, eradicating diseases) (Van Dijk *et al.* 1994).

Vaccines are commercially available for many of the viral diseases of equids (e.g. AHS, EI, EHV, rabies), as well as for several bacterial diseases (e.g. anthrax, tetanus, botulism) (Van Dijk *et al.* 1994). Except for tetanus and botulism, where immunity is directed at the toxins these bacteria produce, these vaccines are directed against the infectious agent. Several vaccines have inherent problems of efficacy. For example, some AHS vaccines do not stimulate immune responses to all of the serotypes of the

virus (Swanepoel 1994a). Attenuated vaccine containing only serotypes 1 to 6 failed to induce adequate cross-immunity to serotypes 7 to 9 of the virus (Blackburn and Swanepoel 1988a, 1988b). The recommended control measures for many diseases affecting wild equids, as mentioned previously, can be obtained from current literature, local or regional veterinary authorities, IUCN SSC, and the OIE (IUCN 1998; Woodford 2001). To be clear, the authors are not advocating the routine vaccination of wild equids! The IUCN SSC Veterinary Specialist Group (Woodford 2001) states:

> "The question of the desirability of vaccination prior to release should be carefully considered and the decision whether or not to immunise the animals to be released should be made by the attending veterinarian after evaluating the immunological status of the animals held in quarantine, and the likely challenge by enzootic and exotic disease agents upon release....
>
> It might be argued that immunisation of translocated animals against enzootic diseases in the release environment is contra-indicated because they would thus be afforded an unfair selective advantage over the resident wildlife. However, this is not necessarily the case, because the resident wildlife would probably have been challenged under natural conditions when young, while under partial protection through colostral immunity, and would presumably have acquired a solid immunity later. In addition, usually only the founder generation of translocated animals would receive vaccine protection.
>
> It is important to remember that some of the potential pathogens…which may occur in a release area are as much a part of the environmental biodiversity as are the animals to be released and have exerted selective pressures on unvaccinated wildlife for a very long time."

Perhaps the most important viral disease of zebras is African horse sickness – the majority of the literature focusing on common (plains) zebras because of the vector-friendly habitat they often occupy. African horse sickness is an acute to subacute systemic illness of horses and other equidae (Coetzer and Erasmus 1994a). The virus is transmitted biologically by insects of the *Culicoides* genus. Four classic forms of the disease have been described: pulmonary, cardiac, mixed, and mild. The most common form is mixed, with malfunction of the pulmonary and cardiac systems secondary to loss of vascular integrity. Horses are the most susceptible, with mortality rates approaching 100%. Mules and donkeys are less susceptible, and zebras are the most resistant (Coetzer and Erasmus 1994a). Zebras do not develop clinical disease following infection with AHS virus; this resistance to disease probably resulted from thousands of years of evolution with the virus and the process of natural selection. Other mammals, including camelids, bovids, African elephants, domestic dogs, and many free-ranging African carnivores have been found positive for AHS antibodies or virus, although the role of these non-equid hosts in the epidemiology of the disease is unknown (Alexander *et al.* 1995). Concerns regarding AHS relate to its potentially devastating effects on domestic horses. Following the outbreak of a viral disease, such as AHS, strong preventive measures must be enforced to limit further transmission of the virus. The specific control measures for AHS, for example, include:

- Establishing a complete ban on the movements of all susceptible animals, especially equids. According to OIE rules, no equids should be allowed to leave the region for a period of two years;
- Protecting equids against vectors by stabling the equids under fine mesh at night, eliminating vector breeding sites, using insecticides and insect repellents;
- Euthanising or immediately isolating all sick animals that may act as a source of virus for transmission of the disease;
- Providing mandatory, immediate vaccination of all domestic equids. In the event of an epizootic, begin vaccinating with an attenuated polyvalent AHS vaccine;
- Identifying the virus serotype(s) responsible for the outbreak, and administering the appropriate monovalent vaccine(s) to induce solid, durable immunity; and
- Notifying the OIE immediately of all cases of the disease.

(Sources: Rodriguez *et al.* 1992a; Rodriguez *et al.* 1992b; Bosman 1994; Coetzer and Erasmus 1994a; Bosman *et al.* 1995.)

Importantly, since the duration of viremia in zebras infected with AHS virus ranges from 11–30 days, the importation of zebras into countries free of AHS should be considered cautiously, and preferably be restricted to serologically negative zebra (Barnard 1994; Barnard *et al.* 1994a). Note that the incubation period between vector bite and sero-conversion can be over two weeks (4–17 days) in zebras, a serious consideration when establishing the duration of quarantine periods.

The control of bacterial diseases of domestic and wild equids is equally crucial. The most important bacterial disease actually affecting wild zebra populations, for example, is anthrax (*Bacillus anthracis*). Anthrax is an acute, febrile disease of most warm-blooded animals characterised by severe vascular damage, usually with a rapidly fatal course (De Vos 1994). The bacteria form spores when exposed to air and can persist in an organism-spore-organism cycle for years. Transmission is via contact with infective spores, and in horses the most prominent

clinical feature of the disease is often colic (De Vos 1994). A summary of the several control measures for anthrax follows for illustrative purposes. A live, avirulent spore vaccine developed in South Africa provides the major method of anthrax control throughout the world (De Vos 1994). The Sterne vaccine is non-pathogenic in domestic and many wild animal species, providing effective immunity within one week of vaccination in some species (it may take up to four weeks or more in horses) that generally lasts for nine months in domestic animals. However, the yearly inoculation of susceptible wildlife populations against anthrax is generally prohibitively expensive, time-consuming, and impractical (Berry 1993).

When an anthrax carcass is opened, the bacteria that are exposed to air form spores that are resistant to the extremes of temperature, chemical disinfection and desiccation. Thus, to prevent sporulation of *Bacillus anthracis*, carcasses should not be opened. The recommended procedure for disposal is burning, or burial of the carcass to a depth of two metres and then covering it with a specific mixture of chloride of lime (De Vos 1994). High concentrations of chemicals such as formaldehyde, glutaraldehyde, hydrogen peroxide, or peracetic acid are useful to inactivate spores; the World Health Organisation (WHO) has established guidelines for the disinfection of *Bacillus anthracis* material (De Vos 1994).

In the event of an outbreak of anthrax in domestic animals, the following control measures are indicated (De Vos 1994):

- Vaccinate all livestock and game animals on the premises (when possible);
- Isolate exposed animals under authorised veterinary supervision for two weeks after vaccination;
- Euthanise and dispose of infected animals under supervision. Treatment of valuable animals in the early stages of infection can be attempted with appropriate antibiotics.

Anthrax has almost been eliminated from domestic animals in South Africa with the above methods, yet the disease is still a major threat to wildlife populations. Disease is often a natural ecological factor that, in many cases, can control populations as predation does. In Namibia's Etosha National Park, for example, anthrax is considered to be a major population-limiting factor in several plains ungulates (Ebedes 1977; Berry 1981, 1993; Turnbull *et al.* 1986, 1989, 1992; Lindeque and Turnbull 1994; Gasaway *et al.* 1996). According to Young (1973) and De Vos (1994), herd animals such as common zebra (*Equus burchellii*), blue wildebeest (*Connochaetes taurinus*), and African buffalo (*Syncerus caffer*) can be boma-captured and vaccinated (with some difficulty) from the sides of a crush. De Vos *et al.* (1973) developed an aerial method of immunising free-ranging roan antelope (*Hippotragus equinus*) against anthrax in the Kruger National Park, South Africa that may be applicable to wild equids. Introducing avirulent spores into water supplies as a method of oral vaccination has been investigated as another alternative for mass inoculation, although the immunity is short-lived (Ebedes 1977).

In addition to immunisation, anthrax control in wildlife depends upon the elimination of sources of infection through application of the following management practices (De Vos 1994):

- Fencing-off known anthrax hot-spots;
- Instituting a continuous surveillance system to detect outbreaks early;
- Locating and incinerating carcasses immediately to prevent their destruction by scavengers, and subsequent dispersal of spores;
- Replacing natural waterholes with concrete drinking troughs if intermittent disinfection is considered a realistic possibility;
- Fencing-off open waters that have been infected by vultures; and
- Preventing contamination of drinking water by vultures by erecting branch barriers.

The anthrax control methods listed above are considered temporary measures that cannot effectively eliminate anthrax permanently. The long-term control of anthrax should be directed at improving management practices. Improving the quality of vegetation and eliminating contaminated artificial water supplies will force migrating animals to move out of enzootic areas, thus preventing overcrowding and reducing disease transmission (Ebedes 1977).

12.3.3 Disease transmission and reintroduction

All wild equids destined for translocations, re-introductions, or other movements should undergo pre-shipment (and often post-shipment) quarantine procedures (Young 1973). When wildlife managers are considering such movements of wild equids, the following advice from Woodford and Rossiter (1993) should be heeded:

> "Each case must be separately evaluated, taking into account all biological, ecological, geographical, and epidemiological circumstances. Only then will the inherent risks in moving potential 'disease packages' across the world be minimised, and the chances of failing to establish a healthy new wild population significantly reduced."

Quarantine periods for wild equids should be established for a minimum of 30 days. In addition to visual and physical examination (when possible) and evaluation of any observed abnormalities, disease screening for wild equids in quarantine should include a protocol similar to

the following, based on recommendations for domestic equids (Woodford and Rossiter 1993; Phillips 1999; Woodford 2001). Note that movement of non-domestic equids from *ex situ* captivity (for example – in a North American zoo) back to an area within their natural range would mandate screening for diseases known to occur in the region of captivity (Wolff and Seal, 1993). Such diseases (such as the equine encephalitides of the family Togaviridae) are not necessarily discussed in this chapter.

Recommended biomedical precautions to be taken:

- Clinical haematology testing (complete blood count, serum chemistry profile, haematocrit);
- Bacterial cultures as indicated, such as for contagious equine metritis (*Taylorella equigenitalis*);
- Urinalysis, if feasible;
- Fecal examination for endoparasites;
- Fecal larval culture (especially for lungworm);
- Baermann tests for lungworm larvae (especially for wild asses);
- Serological tests: for example-African horse sickness (VN), equine encephalosis virus (VN), equine infectious anaemia (AGID), equine arteritis virus (VN), equine herpes viruses (CF), equine influenza (hemagglutination inhibition) (HI), glanders (*Pseudomonas mallei*) (CF), dourine (*Trypanosoma equiperdum*) (CF); West Nile virus (consult relevant authorities);
- Viral isolation, as indicated;
- Blood smears for haemoparasites (*Babesia* spp., *Besnoitia bennetti*) (Perform serology on animals with negative blood smears);
- Buffy coat smears for trypanosomes (*Trypanosoma brucei, Trypanosoma evansi)* (Perform ELISA test for negative samples);
- Ectoparasite checks (treat if necessary);
- Treatment for endoparasites;
- Vaccination of equids based on local and regional disease concerns, (such immunisations may include, but are not limited to: African horse sickness, rabies, tetanus, anthrax, equine influenza, equine herpes viruses, equine encephalomyelitis, strangles, and botulism). Killed vaccines are generally safer than modified-live vaccines, given that commercial vaccines are tested and approved for domestic equids;
- Collection and freezing of labelled serum and tissue samples; and
- Permanent identification of animals by ear tag, tattoo, and/or microchip.

For an example of a "real world" approach to equid disease screening and monitoring, see Walzer *et al.* (2000): the authors present a summary of current veterinary issues surrounding Przewalski's horse reintroduction to Mongolia.

12.3.4 Summary and future conservation priorities

As wild animal populations diminish and the urgent need to conserve them intensifies, the importance of disease in wildlife populations becomes more obvious (Pastoret *et al.* 1988; Hutchins *et al.* 1991; Ballou 1993; Kirkwood 1993; Lyles and Dobson 1993; Meltzer 1993; Woodford 1993; Woodford and Rossiter 1993; Wolff and Seal 1993; Gull and 1995; Cunningham 1996; Daszak *et al.* 2000; Bengis 2002a; Bengis 2002b). Infectious agents can exert important effects on host population dynamics. Before control of diseases in wildlife is possible, there is a need for increased understanding of the dynamics of infections in wild and domestic animal populations. Detailed field studies are required if one hopes to determine the distribution of diseases in wild animal populations and to elucidate interactions between the environment, host genetics, and immune responses (Gulland 1995). Collaboration between domestic animal health authorities and wildlife management agencies can only enhance surveillance efficiency. Thorough postmortem examination and sample collection protocols (Woodford 2000) must be part of any endangered species recovery project. If nothing else, readers of this chapter's text and tables should note how much our current understanding of animal disease depends on thorough necropsy efforts (and pathologists). The involvement of veterinarians and other wildlife disease experts in field investigations of disease outbreaks and/or mortality events is therefore paramount.

Securing solutions to conservation problems facing wild animals and their habitats will require careful multidisciplinary work (Karesh *et al.* 2002). With the remaining populations of most wild equids under threat, their survival will certainly depend on careful management, and the veterinary implications of this reality will be enormous (Hutchins *et al.* 1991).

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