The first meeting of the Group was held on 1-4 March 1993 at OIE headquarters.

It was opened by Dr J. Blancou, Director General of the OIE, who welcomed the participants (listed in Appendix I). Dr M.H. Woodford was elected chairman of the meeting, and Drs R. Bengis and M. Artois were chosen as rapporteurs. The agenda (Appendix II) was approved.

A major objective of the Ad hoc Group on Wildlife Diseases was to identify those wildlife diseases of concern to Member Countries and those that should be considered for reporting to the OIE. To assist in this task, a questionnaire (Appendices III, IV and V) was sent in advance by the OIE to 125 Member Countries, requesting a list of diseases of wildlife in their country or region that are recognised as having an important impact on domestic livestock, poultry or humans, and another list of those diseases recognised as having an important impact solely or mainly on wildlife populations. Respondents were also asked to identify diseases of domestic animals, poultry or humans which have or could have an important impact on wildlife populations in their country.

1. Analysis of questionnaire
The wildlife disease questionnaire was sent to 125 Member Countries. 48 countries (38.4%) responded, with the following arbitrarily grouped geographical distribution and response rates:

<table>
<thead>
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<th>Region</th>
<th>Responded</th>
<th>Total</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Europe</td>
<td>14/18</td>
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<td>35</td>
<td>31%</td>
</tr>
<tr>
<td>North Africa and Middle East</td>
<td>7/17</td>
<td>17</td>
<td>41%</td>
</tr>
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</table>

An analysis of the answers to these questionnaires received demonstrated the following:

1.1. Summary of the diseases

a) Of those diseases considered by Member Countries to have wildlife significance, ten were OIE List A diseases. These diseases are: African horse sickness, African swine fever, bluetongue, foot and mouth disease, hog cholera (classical swine fever), peste des petits ruminants, rinderpest, Rift Valley fever, fowl plague, Newcastle disease;

b) a further 21 important wildlife diseases were already on OIE List B. These diseases are the following: anthrax, Aujeszky's disease, bovine tuberculosis, brucellosis, cowdriosis (heartwater), echinococcosis, equine encephalomyelitis, leishmaniasis, malignant catarrhal fever, rabies, screwworm (Cochliomyia hominivorax), theileriosis, trichinellosis, trypanosomiasis, avian tuberculosis, duck plague (duck virus enteritis), fowl cholera (avian cholera), psittacosis (ornithosis), myxomatosis, tularaemia, and viral haemorrhagic disease of rabbits;

c) from responses by Member Countries, a preliminary list was drawn up comprising an additional 30 diseases which do not appear on either Lists A or B, but were identified as important because wild animals are involved in their epidemiology as actual or potential victims, carriers, or disseminators. These diseases deserve consideration for reporting and inclusion on a "wildlife disease waiting list". These diseases are the following:

For mammals: Baylisascaris spp., besnoitiosis, canine distemper, contagious ecthyma, crassicaudosis, elaephorosis, epizootic haemorrhagic disease, erysipelothrrix, European brown hare syndrome, feline panleucopenia, feline leukaemia, large liver fluke of deer, Lyme disease, mange, psoroptic mange, meningeal worm of white-tailed deer, meningeal worm of old world cervids, oculo/vascular myiasis (gedoelstiasis), phocine distemper, calicivirus disease of marine mammals, plague (sylvatic), salmonellosis and toxoplasmosis, Tyzzer's disease;

For birds: avian pox, avian malaria, heartworm of swans, histomoniaisais, inclusion body hepatitis and trichomoniasis.
Respondents to the OIE questionnaire also reported other disease and parasite problems which were considered to be of lesser priority by the Ad hoc Group. Reasons for a low priority listing included that: the disease problem was non-specific, i.e. "ectoparasites", or the Group was not convinced that wildlife were involved in the disease epizootiology, or the disease nominated was considered ubiquitous and/or of minor pathologic importance. Diagnostic methods may also not be standardised. Additional information would be required before the Ad hoc Group would recommend these diseases for reporting.

1.2. Ranking of the diseases

a) Regarding the question asked of Member Countries, "What infectious or parasitic diseases of free living (or farmed) wildlife are present in your country, or region, by host species, which are recognised as having an important impact on domestic livestock, poultry or human beings?" (Question 1a), answers for List A and B diseases by the arbitrarily grouped regions are summarised in Appendix III.

Of the OIE List A diseases, it is clear that Member Countries consider Newcastle disease important in this category. In regions where the diseases are present, African swine fever and foot and mouth disease (FMD) are also considered important.

Of List B diseases rabies, echinococcosis, tuberculosis, brucellosis and psittacosis were among several considered of importance.
b) For the question which asked, "What infectious or parasitic diseases of free living (or farmed) wildlife are present in your country, or region, by host species, which are recognised as having an important impact solely or mainly on wildlife populations?" (Question 1b), a summary table of responses is given in Appendix IV.

Among List A diseases, Newcastle disease also strongly dominated in this category. Considered next in importance was FMD.

For List B diseases rabies was the most frequent answer, followed by anthrax, tuberculosis, brucellosis, and myxomatosis.

c) Also asked was the question, "What infectious or parasitic diseases of domestic animals, poultry or humans are present in your country/region which have (or could have) an important impact on wildlife populations?" (Question 2). A summary table is given in Appendix V.

For List A diseases, Newcastle disease also predominated in this category, followed by FMD, rinderpest and hog cholera.

Of List B diseases, bovine tuberculosis, followed by brucellosis and anthrax, were the most frequent answers. Rabies in domestic animals was also frequently considered a risk to wildlife populations.

d) Of the many proposed "wildlife disease waiting list" (non A and B) and other miscellaneous diseases reported by Member Countries, there was great variation in description of the etiologic agent and hosts involved, and of regional emphasis. For these reasons, no tabulation is enclosed in the report. A brief resumé of those mentioned most in the responses follows, in decreasing order of times which they were listed:

Question 1a: Salmonellosis, leptospirosis, toxoplasmosis, Lyme disease, various poxes.

Question 1b: Mange, coccidiosis, lungworms, pasteurellosis, toxoplasmosis, canine distemper, leptospirosis, European brown hare syndrome.

Question 2: Canine distemper, leptoSpirosis, fascioliasis, bovine virus diarrhoea, canine parvovirus.

2. An overview of wildlife diseases

The Group felt that Member Countries might consider of interest and/or use an overview of what is known of the involvement of wildlife in various diseases. Appendix VI contains a brief description of each of the diseases, according to List A, List B, and the proposed "Wildlife disease waiting list", which are considered significant to wildlife, domestic livestock, poultry or humans on a widespread or local basis. Wild animal genera and species referred to are listed in Appendix VII.

3. Reporting of wildlife diseases

With regard to the reporting of wildlife diseases and parasites to the OIE, the Ad hoc Group strongly recommends that diseases on OIE Lists A and B should be reported whenever they are found in wildlife, whether they occur in birds or terrestrial or aquatic mammals. The Group requested the International Animal Health Code Commission to address the subject of marine mammals in the definition of animals in the Code. Furthermore, reports of wildlife disease outbreaks to the OIE should specify the
genus and species of the wild animals involved and where possible a detailed epizootiologic account should be provided. The Ad hoc Group also recommends that the additional 30 diseases identified as important for wildlife but not included in Lists A or B should be considered for inclusion on a "waiting list" for the OIE reporting process.
In the interim, these diseases could be reported voluntarily on an annual basis, as is done for List B diseases of livestock in accordance with Article 1.2.0.3. Section 1d of the International Animal Health Code.

The Ad hoc Group also recommends that the occurrence of any wildlife disease covered in List A and B or on the "waiting list", should be reported:

a) by each Member Country's OIE Delegate to that country's wildlife conservation agencies.
b) by the OIE Central Bureau to appropriate international agencies concerned with wildlife.

Similarly OIE country Delegates might encourage national wildlife research and conservation agencies to inform them when outbreaks of disease in wildlife are observed or suspected.

4. Disease considerations for wildlife translocation

a) Several disease risk problems are associated with translocation of and trade in wildlife. The most obvious is the direct introduction of a new wildlife or domestic animal disease as a result of the translocation. This event has occurred on many occasions and as a result serious diseases such as bovine tuberculosis, rabies and echinococcosis have become established in previously uninfected areas. A second problem can occur when a wildlife species is introduced which facilitates the transmission of an existing problem disease. A good example of this has been the introduction of the brush-tailed possum (Trichosurus vulpecula) into New Zealand and its subsequent development as a bovine tuberculosis reservoir. A third type of risk occurs when the translocation and subsequent multiplication of a wild species creates an artificially high stocking density which facilitates transmission of endemic diseases. Further problems may arise if immunologically naive species or individuals are introduced into endemic disease areas or into environments which are seriously polluted or otherwise ecologically unsuitable.

The relocation of wildlife never consists of the movement of a single species. Living animals are "biological packages" consisting of the host animal and its passenger organisms which may include viruses, bacteria, fungi, protozoa, helminths and arthropods. Such "passenger" organisms are often non-pathogenic for the host being introduced because the host and organism have adapted to each other over time. Unfortunately, introduction of an exotic wildlife species containing disease agents, which are also themselves exotic, can pose an acute problem for indigenous wildlife species. Extermination of native wild birds in Hawaii due to the introduction of avian malaria is a good example of this scenario.

To prevent disease problems associated with wildlife in transport and trade, a thorough and cautious evaluation must be made prior to the proposed introduction. Inherent to wildlife introduction is the fact that these animals are difficult or impossible to retrieve once they are released or have escaped into new areas. Therefore, release or escape of infected or diseased wild animals must be considered irreversible.
b) The Group discussed the history of several important diseases which have spread by the transport of wildlife, considered those international aspects regarding certain diseases in the *OIE International Animal Health Code*, and made the following recommendations about the translocation of wild species, either within countries or internationally:

The first measure of disease risk evaluation for wildlife translocation is a complete literature search of diseases and parasites of the species involved. This should be combined with consultation with wildlife disease experts so that diseases of concern can be jointly identified by livestock and wildlife health authorities in the recipient country or area. A second step should be a health assessment of wild or captive animals in the source population. Although not always possible, it is desirable to conduct a full necropsy study and laboratory sampling of some of the animals from within the native habitat. Long-term surveillance data, if available, may have to be used as a substitute. In some instances, native species may have to be infected experimentally with diseases of introduced species in order to evaluate the potential for problems.
Wild animals being imported should be subjected to rigorous disease and parasite screening. In some instances prophylactic treatments such as acaricides, anthelmintics, antibiotics and vaccines should be administered. Quarantine periods should be determined by the specific disease risks. The use of sentinel animals at destination quarantine stations should be considered. The regulatory agency responsible for animal health should not submit to political pressure for urgent wildlife translocation projects and should qualify its decisions by stressing the potential irreversibility of a disease introduction.

Prior to release there should be a contingency plan for dealing with an unfavourable, introduced disease outbreak. Post-release health monitoring of translocated wildlife, indigenous wildlife and domestic animals in the release area should always be carried out for those diseases of potential concern. Official veterinary services should avail themselves, when possible, of recent advances in germ plasm technology since translocation of germ plasm presents a greatly reduced disease risk.

Further details on this important topic are provided by reference to Appendix VIII and to Woodford M.H. and Rossiter P.B. Disease risks associated with wildlife translocation projects - Rev. sci. tech. Off. Int. Epiz., 1992, 11, (4) and to Vol. 7 (4), Dec. 1988, of the same journal.

5. List of wildlife disease consultants

Recognising that wildlife disease expertise on a global scale is a scarce commodity, the Ad hoc Group recommended that OIE should establish and maintain a register of appropriate specialist consultants who are recognised international authorities on a wide range of diseases of wild animals. These consultants would be expected to provide advice on request for the prevention, control, and where appropriate, treatment of diseases of wildlife to the OIE Member Countries.

6. Wildlife disease database

Recognising that suitable habitats for wildlife are shrinking worldwide and that as a result there is an increased susceptibility and vulnerability of some species to infectious disease; and further recognising that game farming activities are increasing and as a result health problems in wildlife may be anticipated due to:

a) The establishment of wild animal populations in areas of unsuitable habitat
b) Overcrowding and malnutrition
c) Introduction of animals harbouring disease agents or parasites,

the Group recommends that a comprehensive database of wildlife disease literature should be set up and maintained at the OIE Central Bureau. The publication of a review manual on the most important diseases of free-living wildlife should be considered.

7. Other matters
a) The Group recommended that OIE should request the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to allow the unobstructed transportation of bona fide veterinary diagnostic specimens derived from animals listed on CITES schedules 1 and 2 across international borders en route to wildlife disease laboratories. These diagnostic samples must, of course, comply with the zoosanitary regulations of the importing country’s Veterinary Service. OIE might point out to CITES that these specimens have no commercial value and that prompt diagnosis of wildlife diseases has significant conservation implications.

b) The Ad hoc Group recommended that in order to review the evolving trends in wildlife diseases on a global scale, the Group should meet at regular intervals at the OIE Central Bureau. After discussion with the Central Bureau it was agreed that the proposed terms of reference of the Group will be the following:
In close cooperation with the OIE Specialist Commissions and Working Groups:

1. To propose a regular wildlife disease reporting system (through OIE regular publications) and to suggest ways of promoting reporting.

2. To review periodically evolutions of disease problems of free living and farmed or ranched wildlife which are significantly (or potentially) important to these populations or to livestock, poultry, or humans.

3. To advise on measures (and/or research) to prevent, control or where appropriate treat these diseases.

4. To assess developments in wildlife populations and their conservation or utilisation which can be significantly influenced by disease, and to propose measures (and/or research) to forecast, prevent and control these diseases in both wild and domestic animals.

5. To summarise the disease risk problems in the transport and commerce of wildlife and their products and to propose measures to prevent them.

6. To update regularly techniques for improved diagnosis and surveillance of wildlife diseases.


.../Appendices
REPORT OF THE MEETING
OF THE AD HOC GROUP ON WILDLIFE DISEASES

Paris, 1 - 4 March 1993

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REPORT OF THE MEETING
OF THE AD HOC GROUP ON WILDLIFE DISEASES

Paris, 1 - 4 March 1993

Agenda

1. Analysis of questionnaire sent to Member Countries
2. An overview of wildlife diseases
3. Reporting of wildlife disease
4. Disease considerations for wildlife translocation
5. List of wildlife disease consultants
6. Wildlife disease database
7. Other matters
**LIST A AND B DISEASES MENTIONED IN RESPONSE TO QUESTION 1A OF THE QUESTIONNAIRE**

"What infectious or parasitic diseases of free living (or farmed) wildlife are present in your country, or region, by host species, which are recognised as having an important impact on domestic livestock, poultry or human beings?"

<table>
<thead>
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<th>Diseases</th>
<th>Sub-Saharan Africa</th>
<th>North Africa &amp; Middle East</th>
<th>North &amp; South America</th>
<th>Australia &amp; Oceania</th>
<th>Western Europe</th>
<th>Eastern Europe &amp; Asia</th>
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Figures in the table denote the number of times a disease was reported in answer to this question by the responding countries in the geographic region.
LIST A AND B DISEASES MENTIONED IN RESPONSE TO QUESTION 1B OF THE QUESTIONNAIRE

"What infectious or parasitic diseases of free living (or farmed) wildlife are present in your country, or region, by host species, which are recognised as having an important impact solely or mainly on wildlife populations?"

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Figures in the table denote the number of times a disease was reported in answer to this question by the responding countries in the geographic region.
**LIST A AND B DISEASES MENTIONED IN RESPONSE TO QUESTION 2 OF THE QUESTIONNAIRE**

*What infectious or parasitic diseases of domestic animals, poultry or humans are present in your country/region which have (or could have) an important impact on wildlife populations?*

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<th>Diseases</th>
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<th>North &amp; South America</th>
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**LIST B DISEASES**

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Figures in the table denote the number of times a disease was reported in answer to this question by the responding countries in the geographic region.
WILDLIFE ASPECTS OF DISEASES ON LISTS A AND B AND THE PROPOSED "WAITING LIST"

LIST A DISEASES: WILDLIFE ASPECTS

African horse sickness

An apparently subclinical disease of zebra species; nine serotypes of African horse sickness (AHS) orbivirus have been identified. Domestic equidae are susceptible and suffer high mortality. Because of the importance of this disease, effective vaccines have been developed. Culicoides are the biological vectors of this disease. It appears that AHS was introduced into Europe in the past with zebra (Equus burchelli) importations from Africa.

African swine fever

This iridovirus infection is endemic in wild suidae, and their soft tick vectors in Africa. The disease has spread to domestic, feral and wild swine alike in Africa, Europe, the Caribbean and South America. The disease has been eradicated from the latter two regions. Strains of virus vary in their pathogenicity. No effective vaccine has been developed. There are inapparent carriers of the virus in both domestic and wild swine.

Bluetongue

This disease, caused by an orbivirus, occurs enzootically throughout the world in most tropical and subtropical regions. More than 25 viral strains are known with varying distribution and pathogenicity worldwide. Occasionally high mortality occurs in susceptible domestic and wild ungulates. Biting midges of the genus Culicoides are biological vectors.

Foot and mouth disease

It is well known that the Cape buffalo (Syncerus caffer) is a carrier of the FMD SAT virus serotypes in Africa, with apparently little or no significant effect on their populations. Although infection may spill over to livestock, several African countries have programmes which have successfully prevented or controlled this spread. FMD in both buffalo and domestic livestock populations is an important source of outbreaks in satellite cloven hooved wildlife species.

Hog cholera (classical swine fever)
Wild and domestic swine alike suffer high morbidity and mortality from this viral disease. Cross transmission from domestic to wild swine, and vice versa, has been an important consideration in disease eradication programmes.

Peste des petits ruminants

The virus is closely related to that causing rinderpest. The disease is a severe problem in goats and sheep, and is rapidly extending its geographic range. Wild ungulates in zoos have suffered severe mortality; however, naturally occurring cases in free living wildlife have not yet been recorded.

Rinderpest

Occasional serious outbreaks have occurred in wild ungulates. This viral disease usually causes high mortality in susceptible wild and domestic ungulates. No carrier state is known to exist. Once it is controlled by vaccination in domestic animals, the disease dies out even in susceptible wildlife populations.
Appendix VII (contd)

Rift Valley fever

This cyclical arthropod-borne viral disease causes high morbidity with varying mortality in a wide variety of domestic and wild mammals and humans. No interepidemic wild or domestic mammal with reservoir status has been identified.

Fowl plague

More than 100 serotypes of avian influenza virus occur in nature and they vary as to their pathogenicity and ability to be transmitted among species, including birds, domestic mammals and humans. Outbreaks in domestic poultry have generally been considered to have wild birds as a source. The term "fowl plague" has been used to describe one specific serotype (H7N7) but other serotypes have also been shown to be highly pathogenic for domestic poultry.

Newcastle disease

This virus disease has also been clearly shown to be an important disease of both domestic and wild birds, with potential for transmission between species. Both eradication and prevention programmes include special attention to captive wild species, particularly psittacines and pigeons. High mortality has occurred in cormorants, pelicans and gulls in North America.

LIST B DISEASES

Anthrax

In wildlife, anthrax is usually an acute septicaemic disease which results in very high mortalities. The anthrax bacterium is an environmental contaminant, which infects wildlife following ingestion of infected food or water, or less commonly, following inhalation or infection by biting flies. It is the only pathogen known which must kill its host to propagate itself in its environment.

Cyclical focal outbreaks or large scale epidemics may occur in wildlife. In free-living wildlife, anthrax has been documented in numerous ungulates, carnivores, perissodactyls, elephants and ostriches. The distribution of anthrax is worldwide and is associated with alkaline soils.

Anthrax is a highly significant cause of mortality in wildlife on some continents, because infected carcasses lying in the field are opened by predators/scavengers, stimulating sporulation and environmental contamination.

Aujeszky's disease (pseudorabies)
Aujeszky's disease is caused by a herpesvirus which is widespread in domestic swine in North America and parts of Europe. Infection has been documented in feral swine in the United States and in wild boar in some European countries. In domestic swine, Aujeszky's disease is important because it causes abortions and weak piglets. Adult swine are asymptomatic carriers of the virus. Transmission is usually by direct contact or by nasal secretions. Feral swine and wild boar populations do not appear to be negatively affected by the presence of Aujeszky's disease. Wild carnivores in close association with infected domestic swine can develop fatal neurologic disease as can domestic animals such as cattle, cats, and dogs. Many countries are eradicating Aujeszky's disease from domestic swine, but wild swine could become a permanent virus reservoir.
Appendix VII (contd)

Bovine tuberculosis (*Mycobacterium bovis* infection)

This bovine disease is capable of infecting numerous wildlife species. The source of infection in wildlife is always considered to originate from infected domestic stock or man. This disease may cycle long term and become endemic in certain wildlife species, whereas in other species individual animals are incidentally infected. This disease has an almost worldwide distribution. In free living wildlife it has been documented in:

1. Africa
   
   a) Cape buffalo, lechwe (*Kobus leche*), kudu (*Tragelaphus strepsiceros*), warthog (*Phacochoerus aethiopicus*) - endemic
   b) black rhino (*Diceros bicornis*), grey duiker (*Sylvicapra grimmia*), springbok (*Antidorcas marsupialis*), elephant (*Loxodonta africana*) and giraffe (*Giraffa camelopardalis*) - incidental

2. Europe

   cervids and badgers (*Meles meles*) (UK and Ireland) - endemic

3. The Americas

   a) wood bison (*Bison bison athabascae*) - endemic
   b) captive cervids - incidental

4. New Zealand

   a) possums (*Trichosurus vulpecula*) and cervids - endemic
   b) mustelids and wild pigs - incidental

5. Australia

   feral water buffalo (*Bubalus bubalis*) and wild pigs - endemic

Transmission is usually by inhalation (droplet infection) or ingestion of contaminated material. Both positive and negative results of tuberculin tests in wild species are notoriously difficult to interpret.

Brucellosis

Species of *Brucella* have proclivities to both domestic and wild hosts, with cross transmission common. *Brucella suis* causes disease in wild hare and infection is present in reindeer/caribou (*Rangifer tarandus*) and wild boar (*Sus scrofa*) populations. There are several isolates from and serological evidence for infection in a variety of wild ungulates, but the significance of these is generally unknown. Livestock have been considered
the origin of wildlife infection, as with endemic *B. abortus* in bison (*Bison sp.*) and elk (*Cervus elaphus*) in North America and buffalo in Africa.

Cowdriosis (Heartwater)

Heartwater is caused by *Cowdria* sp., a rickettsia-like organism which proliferates in vascular endothelial cells, affecting capillary permeability, and resulting in death from brain and pulmonary oedema. Fluid accumulation in all body cavities is also seen. This disease occurs in sub-Saharan Africa and Madagascar as well as on three Caribbean islands.
Heartwater is an acute febrile disease of cattle, goats and sheep, and clinical symptoms include prostration, paddling movements, opisthotonus and dyspnoea, followed by death. Certain wildlife species, e.g. eland (*Taurotragus oryx*), springbok and black wildebeest (*Connochaetes gnou*) have reportedly succumbed to this disease, due to their immunologically naive status prior to being introduced into endemic areas from areas where the vectors do not occur.

Ticks of the genus *Amblyomma* are the only known biological vectors of this disease. Free-living Cape buffalo, guinea fowl and tortoises may serve as sylvatic reservoirs of infection. The reservoir status of other wild African ungulates is unknown.

Echinococcosis

Adult forms of the tapeworm *Echinococcus multilocularis* are found in the intestines of healthy foxes, coyotes (*Canis latrans*), other wild canids, and domestic dogs and cats. Larval forms are found in the liver of rodents, particularly *Microtus* spp. and *Peromyscus* spp. Humans may develop alveolar hydatid disease, a severe and often fatal larval infection, after ingesting eggs passed in the faeces of the definitive host. This is in contrast to unilocular hydatid disease of humans caused by larval forms of the related tapeworm, *E. granulosus*. *E. multilocularis* occurs throughout the northern hemisphere. In North America its range has increased from the arctic tundra zone to a large portion of the north central United States. The chance for further spread of this parasite is increased by the translocation of infected canids from endemic areas to fox-chasing enclosures in the south-eastern United States. In East Africa many wild carnivores are the final hosts of *E. granulosus*. Domestic and wild herbivores (and occasionally, man) act as intermediate hosts.

Equine encephalomyelitis (Arboviral encephalitides)

A large number of different arthropod-borne viruses (arboviruses) are maintained in the wild in cycles involving wild birds, mammals, or reptiles as asymptomatic virus carriers, and biting arthropods as vectors. Some of these viruses are pathogenic for aberrant hosts such as domestic livestock, poultry or humans. Notable examples are the equine encephalomyelitis viruses (eastern, western and Venezuelan) which are maintained in small birds and rodents, and transmitted by mosquitoes without harm to wildlife populations. Infection of horses, humans or some captive poultry (pheasants and ostriches) can cause fatal neurologic disease.

Each arbovirus has a separate wildlife/arthropod maintenance system in nature but none are known to have a serious impact on wildlife populations. The importance of arboviruses is to those accidental hosts that receive virus from biting mosquitoes, flies or ticks. The overwintering host status of some snakes in infected countries should be considered when importation of these reptiles is planned.

Leishmaniasis
This zoonotic protozoal disease is caused by several different species of the genus *Leishmania*. In humans a distinction between cutaneous and visceral forms of the disease is made. Numerous wild mammalian species including wild canids, rodents, procyonids, mustelids, hyraxes (*Hyracoidea*) and wild felids have been reported to play a role in the sylvatic cycle. In recent years, domestic dogs have become epidemiologically more important.

In many parts of the world this disease is transmitted in the sylvatic cycle as well as in the peridomestic (anthropozoonotic) cycle, by dipterous biting flies of the genus *Phlebotamus* (sand flies). In South America, sand flies of the genera *Lutzomyia* and *Psychodopygus* are involved. The distribution of this disease is limited to areas where these arthropod vectors are present.
Malignant catarrhal fever

This is a sub-clinical non-pathogenic herpesvirus disease of blue (*Connochaetes taurinus*) and black wildebeest, goats and sheep. The alcelaphine (hartebeest) associated disease is limited in nature to sub-Saharan Africa but also occurs in zoological gardens worldwide, especially in cervids.

The sheep/goat associated malignant catarrhal fever (MCF) has an almost worldwide distribution. The importance of this disease is its high pathogenicity for domestic cattle, farmed deer and cervids. Mortality rates approaching 100% of infected individuals are normal. MCF is, however, a dead end disease in bovids and cervids with no horizontal or vertical transmission occurring.

Face flies and nasal oestrid flies may act as short distance vectors, because virus is present in oculo-nasal secretions of wildebeest calves during their first four months of life.

From the wildlife perspective, MCF is important because wildebeest are a sub-clinical source of infection, and outside Africa wild and farmed deer and some bovids develop severe clinical disease with high mortality.

Rabies

Several lyssavirus serotypes are involved in rabies epizootics in wild and domestic species on every continent except several Pacific countries, islands and the Antarctic. Although every mammal is susceptible to the infection, few species are considered capable of maintaining epizootics of the disease. These species are foxes [red (*Vulpes vulpes*), arctic (*Alopex lagopus*) and grey (*Urocyon cinereoargenteus*)], skunks [striped (*Mephitis mephitis*) and spotted (*Spilogale putorius*)], raccoons (*Procyon lotor*), raccoon dogs (*Nyctereutes procyonoides*), dogs and jackals [golden (*Canis aureus*)], mongooses and a few other carnivores. Certain species of haematophagous and insectivorous bats are carriers as well. Numerous reported cases in other animals represent victims of cross infection and these species are not considered permanent reservoirs.

Infection of the nervous system provokes an encephalitis responsible for "typical" symptoms and so called "abnormal behaviour". Virus shed in the saliva is transmitted to other animals primarily by bites. Rabies outbreaks in an area may kill up to 80% of a susceptible population. Rabid wild animals transmit lethal infection to man and livestock.

Screwworm (*Cochliomyia hominivorax*)

*Cochliomyia hominivorax*, the New World screwworm, occurs throughout tropical and subtropical America except where it has been eradicated. Myiasis with screwworm fly larvae is an important cause of morbidity and mortality of both domestic and wild mammals. Wild ungulate (deer) populations increased significantly in Mexico and the USA after eradication of *C. hominivorax* from previously enzootic areas. Introduction of the parasite into new areas is a major threat to wildlife. A recently successful eradication programme in Libya cost US$ 75 million.
Theileriosis (Corridor disease)

This disease is caused by *Theileria parva lawrenci*, a protozoal parasite with different stages of its life cycle in the lymphocytes and erythrocytes of its host. The disease has been reported only from sub-Saharan Africa, and requires the presence of African buffalo and certain species of vector ticks to attain endemic status.

Corridor disease is a sub-clinical disease of the African buffalo, which acts as a reservoir of infection. It is non pathogenic in this sylvatic reservoir, but should infected ticks feed on domestic cattle, an acute/sub-acute fatal febrile disease then occurs, characterised by severe lung oedema and dyspnoea, generalised lymphadenopathy and splenomegaly. No horizontal transmission occurs between cattle, and this disease is therefore a dead end disease in cattle.

The ticks *Rhipicephalus appendiculatus* and *Rhipicephalus zambesiensis* are the most important vectors of this disease.

Trichinellosis

*Trichinella* spp. are small nematodes in which the larval form is encysted for a long time in muscle tissue of mammals. Originally it was thought that there was only one species, *Trichinella spiralis*, but several *Trichinella* species, which are not able to cross breed, are now recognised. The infection is cosmopolitan in pigs and in mammals symbiotic with man such as mice and rats. It is also found in more than 100 wild mammal species. Man is incidentally infected by consuming meat infested with encysted larvae. Lethal infections in man have been recorded but remain rare. Infected mammals generally do not suffer clinical signs despite the fact that experimentally infected laboratory rodents show significant modifications of behaviour which can increase the chance of *Trichinella* transmission through predation or cannibalism.

Infection of domestic livestock by a wild reservoir is considered unlikely, since absence or a very low rate of infection is recorded in domestic pigs in Europe and the USA, despite widespread infections in wildlife. Consequently, wildlife infection of humans usually results from consumption of game meat, especially that of bears, walrus (*Odobenus rosmarus*) and wild swine. Unexpected hosts include horses which can provide a source of infection for man.

Trypanosomiasis

This disease is caused by several flagellated haemoprotozoa of the genus *Trypanosoma*. The disease is present in large parts of sub-Saharan Africa, Asia, and South America.

Numerous wildlife species are reservoirs of this disease, and in Africa the tragelaphs, wild suids, wild bovids and elephants are the most important. Other species such as impala (*Aepyceros melampus*), zebra and oryx (*Oryx gazella*) are not important sylvatic reservoirs. Clinical disease is rarely seen in wildlife species, but cattle, horses, swine, camels, small stock and dogs are highly susceptible, and significant mortalities may
occur. Clinical symptoms include chronic wasting and anaemia. Many areas of Africa remained unpopulated by man and his domestic stock, due to the presence of this disease.

Trypanosomiasis is transmitted by several species of tsetse fly (genus *Glossina*) as well as certain biting flies (tabanids), and assassin bugs (Reduviidae) in South America. In Africa, areas infected with these vectors are called "fly-belts". Wildlife involvement with this disease is mainly their role as reservoirs of infection.

Avian tuberculosis

Avian tuberculosis is caused by mycobacteria belonging to the *Mycobacterium avium* complex (MAC). In this group some types are known to be pathogenic, while others are saprophytic bacteria. All avian species are susceptible to *M. avium*, as are man, most species of livestock, and a large number of wild animal species. The disease is found worldwide.

Avian tuberculosis is a chronic granulomatous disease affecting liver, spleen, lungs and intestines in birds, and in mammals the lymph nodes as well. Avian tuberculosis normally occurs as sporadic cases but can become a problem if animals are congregated.

Duck plague (duck virus enteritis)

Duck plague is a disease of anseriform birds (geese, ducks, swans) caused by a herpesvirus. This disease has been reported in domestic ducks in Europe and North America. One large outbreak has occurred in wild ducks and geese in North America, and sporadic small irruptions have been seen on nearly an annual basis. Fatal infections are acute, with bloody fluid coming from the head and cloaca. Necrotic lesions are seen on the proventriculus and lymphoid tissue of the caecal tonsils. Recovered birds can be chronic carriers that shed virus sporadically. Sudden episodes of high mortality in wild or domestic ducks due to duck plague provide evidence of the importance of this disease.

The degree of cross transmission of the virus between wild and domestic anatidae is unknown.

Fowl cholera (avian cholera)

Fowl cholera is a disease of birds caused by the bacterium *Pasteurella multocida*. The disease is widespread in nature and affects a broad range of wild bird species, particularly waterfowl. Avian cholera manifests as acute mortality of birds and lesions are those of septicaemia and acute enteritis. Transmission is by carrier birds, infected bodily secretions, scavengers and contaminated surfaces. Domestic poultry can also be infected. The role of wild birds and mammals as reservoirs for avian cholera in poultry, or vice versa, is not clearly understood since there are numerous serotypes of the bacterium. At present, cross transmission should not be discounted.

Psittacosis and ornithosis
These are the names for infections caused by the bacterium *Chlamydia psittaci*, which is capable of infecting most animal species including man. The bacterium is found worldwide and infections are reported to occur in several species of birds (for example parrots, pigeons, seabirds, passerines) and mammals (koalas (*Phascolarctos cinereus*), felids, rodents, sheep, etc.). The disease can occur in many forms ranging from acute septicemic disease to eye infections and abortions. Transmission is direct or indirect. Ornithosis may play an important role in some animal groups/species (parrots, seabirds, koalas). Symptomless carriers often occur. In pen-raised ducks and turkeys ornithosis can be a significant disease.

**Myxomatosis**

This is a disease caused by *Myxoma* virus. The virus was introduced from South America into France in 1952 and subsequently introduced into wild rabbit populations in other European countries and Australia. The virus causes disease in the common rabbit (*Oryctolagus cuniculus*), both wild and domestic. Other rabbit species do not become infected, or act as symptomless carriers. The disease can be peracute with a general viraemia or more acute/chronic with localised dermatitis, especially on the head. It is transmitted directly, indirectly or by vectors. When myxomatosis first appears in a population mortality is high. Following this, mortality decreases and a cyclic pattern occurs with high mortality some years followed by years with low mortality.

**Tularaemia**

Tularaemia is a zoonosis caused by the Gram negative bacterium *Francisella tularensis*. Two biovars are recognised, the more virulent *F. t. tularensis* (type A) found only in North America and the less virulent *F. t. palaearctica* (type B) found in the whole northern hemisphere. The disease is not found in the southern hemisphere. Tularaemia is a disease mainly of rodents and lagomorphs, although a total of some 200 species of vertebrates and about 100 species of invertebrates have been reported to be susceptible to this bacterium. Tularaemia is an acute septicemic disease normally causing high mortality in rodent and lagomorph populations during epizootic outbreaks. More prolonged infections occur, depending on virulence of the bacteria and the host species. Tularaemia is transmitted by direct contact, by vectors or indirectly by contaminated carcasses, food or water.

**Viral haemorrhagic disease of rabbits**

Viral haemorrhagic disease of rabbits (RVHD) is a disease caused by a calicivirus closely related to European brown hare syndrome (EBHS). The disease was first reported from China in 1984 and is today widespread in Europe. RVHD was introduced into Mexico but was successfully eradicated from that country. It occurs in the wild rabbit (*Oryctolagus cuniculus*) and the domestic rabbit, and is an acute viraemic disease involving mainly the liver, lungs and kidneys. Chronic carriers occur. RVHD normally initially causes high mortality in both wild rabbit populations and domestic rabbitries. In wild populations the disease seems to be permanent and after some time a cyclic pattern occurs with high mortality in some years.
Appendix VII (contd)

WILDLIFE WAITING LIST DISEASES

1. Mammals

Baylisascaris spp.

Intestinal ascarids (nematoda) of the genus Baylisascaris occur in several species of carnivorous or omnivorous mammals such as raccoons, skunks, bears and badgers in North America. These ascarids are not considered important to their definitive hosts; however, after the eggs of this nematode are shed in the faeces, the resultant larvae are neurotropic and viscerotropic in small mammals, birds and occasionally, humans. Larval migration causes blindness, ataxia, and paralysis.

Wildlife that are normal hosts for this nematode are asymptomatic carriers; other wild species are victims of larval invasion. Therefore, presence of Baylisascaris could affect wild rodents, lagomorphs and birds. Faecal contamination by Baylisascaris infected animals has caused mortality in domestic poultry and two fatal human cases have been reported.

Besnoitiosis

Besnoitiosis is caused by tissue-dwelling protozoans of the genus Besnoitia. Infection occurs in North America in caribou and in Africa in cattle and some wild antelope species. The parasite is believed to be transmitted mechanically by ectoparasites, particularly biting flies. Infection is manifested by cutaneous protozoal cysts which result in ulcers and secondary bacterial invasion. Little is known of the significance of this disease in wildlife except that mule deer (Odocoileus hemionus) associated with introduced caribou were killed by the infection. Besnoitia in African cattle can cause a serious cutaneous infection (scleroderma).

Canine distemper

Canine distemper, a morbillivirus disease, causes neurological symptoms in canids, mustelids and procyonids worldwide. The disease has occurred in disease free populations of wild carnivores following introduction by infected domestic dogs. The remnant population of black-footed ferret (Mustela nigripes) vanished as a free-ranging animal species due to an outbreak of canine distemper in Wyoming (USA). Wild dogs (Lycaon pictus) suffer frequent outbreaks in eastern Africa and the disease is a major threat to the survival of several isolated populations of this endangered canid. A similar potential risk exists for island grey foxes (Urocyon littoralis) on the Pacific coast of the USA.

Contagious ecthyma

Contagious ecthyma or orf is a disease of sheep caused by a pox virus. The disease causes proliferative, necrotic lesions on mucous membranes of the head and is spread by direct contact or contaminated fomites. There is widespread distribution of this disease in domestic sheep and goats. In North America, wild bighorn
sheep (*Ovis canadensis*) can be infected and severe clinical disease has been reported in isolated groups of these animals. Orf has also been reported from reindeer and chamois (*Rupicapra rupicapra*) in Europe, and in musk oxen (*Ovibos moschatus*) in arctic North America. This disease is a zoonosis.

Crassicaudosis

Crassicaudosis is a parasitic disease of larger whales caused by a giant nematode *Crassicauda boopsis*. Blue whales (*Balaenoptera musculus*), fin whales (*B. physalus*) and humpback whales (*Megaptera novaeangliae*) can be as much as 95% infected. Infection causes a chronic inflammatory reaction in the blood vessels which drain the kidneys and can cause vascular occlusion. Young whales suffer heavy infections due to transplacental transmission. Direct transmission follows urinary contamination of the environment with eggs of the parasite. Premature deaths attributed to *C. boopsis* infection may impede population recovery of affected species.
Appendix VII (contd)

Elaeophorosis

Elaeophora schneideri is a nematode that resides in the carotid and other arteries of deer in North America. The most important asymptomatic host for this parasite is the mule deer (Odocoileus hemionus) but white-tailed deer (O. virginianus), elk (Cervus canadensis) and domestic sheep can be infected. Transmission of the nematode requires tabanid flies as intermediate hosts. Clinical disease due to E. schneideri does not occur in mule deer; however, the nematode frequently obstructs cranial arteries in elk which results in blindness, neurologic disease and avascular necrosis of the cranial extremities. Filariae of E. schneideri cause cranial dermatitis (sorehead) in domestic sheep.

Epizootic haemorrhagic disease

Epizootic haemorrhagic disease (EHD) is caused by an orbivirus which is closely related to bluetongue virus. Worldwide, there are 9 serotypes of EHD virus but not all of them are known to be pathogenic. Serotypes 1 (New Jersey) and 2 (Alberta) are present in the United States and a small part of southwestern Canada. Ibaraki virus in cattle in Japan is closely related serologically to EHD serotype 2. EHD virus serotypes 1 and 2 cause high mortality in white-tailed deer, mule deer, black-tailed deer (Odocoileus hemionus) and pronghorn antelope (Antilocapra americana).

The disease is manifest as an acute febrile illness with systemic endovascular damage that results in oedema, haemorrhage, and mucosal erosions and ulcerations. The biting midge Culicoides variipennis is a known biological vector. The impact on North American deer and antelope populations can be severe with high mortality. Disease in domestic ruminants has not been well documented, although EHD virus has been recovered from sick cattle.

Erysipelothrix

This bacterial disease of sea mammals fatally infects up to 50% of captive dolphins held in oceanariums in parts of the former Soviet Union. The organism, Erysipelothrix rhusiopathiae, has been isolated from fur seals, sea birds, soil and mud on the Komandor and Tuleniya Islands in the Bering Sea and from free-living dolphins in the Black Sea. The organism has a worldwide distribution and opportunistically infects many species including man.

European brown hare syndrome

This is caused by a calicivirus, closely related to the virus causing viral haemorrhagic disease of rabbits (RVHD). Cross infection does not seem to occur between hares and rabbits. European brown hare syndrome (EBHS) is so far reported only from Europe, and occurs only in hares (Lepus europaeus, L. capensis, L. timidus). It is mainly an acute septicaemic disease involving the liver, kidneys and lungs, but chronic cases and symptomless carriers both occur.
EBHS is transmitted directly or indirectly and animals become infected by inhaling or ingesting the virus. EBHS plays an important role in hare population ecology and can also cause mass mortality in farmed hares.

Feline panleucopenia

Feline panleucopenia virus (FPLV) is a parvovirus specific for felids existing throughout the world. Infection is widespread in domestic and feral cats and has been recorded in numerous felid species in zoological gardens. Infection causes enteritis, immunosuppression and general reticulo-endothelial breakdown. Heavy mortality occurs in kittens as well as in non-naturally immunised adults. Up to 80% of cats in dense populations can show serological evidence of previous contact with the virus.
Appendix VII (contd)

The virus is shed in saliva and faeces and is very resistant to environmental conditions; consequently indirect contamination of wild-cat species sharing activity areas with infected free-ranging domestic cats is suspected to occur. FPLV infection of European wild cats (*Felis silvestris*) is generally considered to be a major threat to the survival of this species in isolated or fragmented small populations.

Feline leukaemia

Feline leukaemia virus (FeLV) is a retrovirus (Oncovirus) of worldwide distribution. Most species of felids are susceptible. The virus is associated with neoplastic disease and severe immunosuppression. When infected, susceptible cats can either mount a successful immune response (being only transiently viraemic) or can become persistently infected and die three or four years after the onset of clinical disease.

The virus is transmitted by direct or indirect contact between infected and susceptible cats. Recent reports of frequent infection of European wild cats (*Felis silvestris*) in Scotland, and of some African felids (in unpublished data in France), suggest that feline leukaemia could be a disease of major concern for wild felids.

Populations of wild felids could be initially infected following fights between infected domestic cats and susceptible wild cats. Subsequently the virus could spread and persist in natural populations through intraspecific wild cat contacts. Susceptible felid species such as lynx (*Lynx lynx*) should always be vaccinated prior to release into the wild (translocation or reintroduction) so as to protect them against infection by resident wild or feral domestic cats.

Large liver fluke of deer

The trematode, *Fascioloides magna*, is a liver parasite of North American cervids, e.g. *Odocoileus*, *Cervus*, and *Alces*. It also occurs in fallow deer (*Dama dama*) and red deer (*Cervus elaphus*) in Italy and Germany. The parasites reside in fibrotic capsules in the liver, and eggs are shed in faeces. Aquatic snails are required intermediate hosts and infection occurs when animals eat immature trematodes that are encysted in vegetation. Disease is not apparent in most wild cervids although moose (*Alces alces*) can have serious liver damage. Infection of cattle is not fatal but it results in severe liver damage and organ condemnation at slaughter. Domestic sheep may develop fatal disease due to hepatic trematode migration and secondary *Clostridia novyi* infection.

Lyme disease

The etiologic agent of Lyme disease is a spirochaete, *Borrelia burgdorferi*. The disease was first reported in the Lyme area (Connecticut, USA) in 1977. Infection occurs in North America, seems to be ubiquitous in Europe, and probably occurs worldwide.

Numerous species of wild birds and mammals are frequently found infected. Man is incidentally infected by tick bites acquired when crossing an infected area during warm weather. Disease in man can be serious, causing arthritis and dermatitis. The slow onset of symptoms renders the disease difficult to diagnose in man.
Although the distribution of human cases has been linked to the presence of deer, this relationship is indirect. Deer maintain tick populations but do not appear to propagate the causal organism. Small rodents do, and act as reservoirs.

Mange (sarcopptic)

Mange is caused by different species of mites which are responsible for typical density-dependent mortality in numerous species under natural conditions. High mortality of red foxes (Vulpes vulpes) has occurred following the introduction of Sarcoptes scabiei infection into northern Europe; a similar epizootic of sarcoptic mange is still expanding in chamois (Rupicapra rupicapra) and ibex (Capra ibex) in the European Alps. Mange is said to affect more than 20% of reindeer in northern Russia. Outbreaks have been recorded in many mammals in Africa. Several degrees of severity of the skin lesions are observed; in severe cases the whole body is affected and the animal becomes fatally emaciated, while in some cases the effects are slight.

Transmission is sometimes very efficient resulting from direct skin contact (“grooming”) or by sharing dens or resting places. Interspecies cross infection occurs, causing damage in low density populations of susceptible species particularly when an epizootic spreads through a high density, different species, which acts as a reservoir (e.g. red fox toward arctic fox).

Mange (psoroptic)

The parasitic mite, Psoroptes cuniculi, has been reported as an important disease of bighorn sheep in North America and occasional cases have been reported in white-tailed deer. This mite causes hair loss, itching, cutaneous excoriation and secondary infection of the ears, head, neck and shoulders. Transmission occurs by direct contact with mites or mite eggs shed from an infected animal. The role of wildlife as reservoirs for P. cuniculi is unknown since the taxonomy and host specificity for this parasite is uncertain. Comparable disease has been seen in domestic sheep and domestic rabbits. Clinical disease also occurs in the African Cape buffalo where the causal parasite is Psoroptes pienaari.

Meningeal worm of white-tailed deer

This meningeal worm of deer is a protostrongylid nematode, Parelaphostrongylus tenuis, that resides in the cranial meninges and venous sinuses of white-tailed deer (Odocoileus virginianus). The distribution of this parasite corresponds with the range of this deer species in much of the eastern half of North America.

Infection of many ruminant species other than white-tailed deer can result in migratory damage to the spinal cord and brain. Clinical signs include lameness, lumbar paralysis, blindness, circling, ataxia and total paralysis. Affected species include moose (Alces alces), elk, reindeer/caribou, mule deer, fallow deer (Dama dama), domestic sheep and goats, llamas (Lama glama) and other small ruminants. A terrestrial snail is an obligate intermediate host of the nematode life cycle. The impact of this parasite on susceptible wild ruminant populations can be substantial and it can cause losses in sheep, goats, llamas and game-farmed ruminants.
Meningeal worm of Old World cervids

Elaphostrongylus spp. are the meningeal worms of the Old World cervids. Elaphostrongylus is a nematode of the protostrongylid family. It is reported to infect moose (*Alces Alces*), reindeer (*Rangifer tarandus*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and some other cervids. It is found naturally in the northern hemisphere of the Old World and has been introduced along with host animals to some other parts of the world (North America, New Zealand). Most cervids harbour the parasite without illness, but it is reported to cause high mortality among, for example, reindeer and moose calves. Terrestrial snails and slugs are intermediate hosts, and deer become infected when accidentally ingesting the snails. Meningeal worms present an important risk for deer translocation projects.

Oculo/vascular myiasis (gedoelstiasis)

Flies of the genus *Gedoelstia* normally complete parts of their life cycle in the paranasal sinuses of certain African antelope, such as blesbok (*Damaliscus dorcas phillipsi*), bontebok (*D. d. dorcas*), wildebeest and various hartebeest species.

In Southern Africa, the larval stages of this fly may migrate to the retrobulbar vasculature of aberrant hosts, such as sheep. The resulting tissue reaction and thrombosis of these vessels causes massive swelling of the affected orbit with proptosis and blindness as sequels.

Occasionally, aberrant migration of one of the larval instars in its natural sylvatic host may cause localised meningeal irritation or a focal parasitic neuritis or encephalitis, resulting in circling movements or other neurological signs.
Phocine distemper

This disease is caused by a group of morbilliviruses related to the virus causing canine distemper. An epizootic disease was recorded in 1988 in the North Sea Region in harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). Serological surveys subsequently showed that the virus is present in most seal populations worldwide. In epizootics phocine distemper occurs as an acute viraemic disease, frequently with conjunctivitis and purulent bronchopneumonia. The disease is directly transmitted between seals, predominantly when they congregate on land. The outbreak in the North Sea greatly reduced seal populations, but the impact of the disease on worldwide seal populations is not thought to be serious except for small isolated groups.

Calicivirus disease of marine mammals

This virus disease of marine mammals (fur seals, sea lions (*Zalophus californianus*) and dolphins) was first seen affecting sea lions in the Pacific Ocean region in 1972. The virus, of which more than 20 serotypes have been identified, causes an often fatal vesicular disease in marine mammals and can infect domestic pigs. The virus has also been isolated from fish in the Pacific. Until recently the disease was thought to be confined to North America and Russia but it has now been reported in grey seals (*Halichoerus grypus*) in the United Kingdom. This is the first report of the disease on the European side of the Atlantic.

Calicivirus infection causes vesicular exanthema in domestic pigs and was responsible for a successful multi-million dollar eradication programme in the United States, following an outbreak apparently caused by pigs which had been fed on seal carcasses. Transmission amongst marine mammals is by contact and to domestic pigs initially by infected feedstuffs containing seal meat, followed by horizontal pig to pig transmission.

Plague (sylvatic)

Sylvatic plague of rodents occurs worldwide and is caused by infection with the bacterium *Yersinia pestis*. Fleas, particularly the oriental rat flea, *Xenopsylla cheopsis*, serve as biological and mechanical vectors of the bacteria. *Yersinia pestis* persists in sylvatic populations via factors including commingling of rodent species of varying susceptibility and long-term survival of fleas containing the organism. Epizootics occur in wild rodents when populations are dense, flea infestation is severe, and virulent organisms are present. Bubonic plague in humans occurs when they intrude into the sylvatic cycle or sylvatic rodents and their fleas enter into man’s habitat. Plague infections can overwinter in rodents which hibernate and the sylvatic cycle can be renewed when the animals emerge in the spring.

Salmonellosis

Salmonellosis is an enteric or systemic infection with bacteria of the genus *Salmonella*. There is a large number of species and serotypes of *Salmonella*, some of which are more important than others with regard to pathogenicity. Many mammals, birds, humans, reptiles and amphibians can be asymptomatic carriers of
Salmonella organisms and the distribution of the genus is worldwide. Certain Salmonella species can be highly pathogenic and disease has been reported in wildlife as well as domestic livestock, poultry, and humans. Regular or sporadic episodes of mortality in wild birds or mammals have been caused by Salmonella spp., notably S. typhimurium. Such outbreaks should be reported when they occur.

Toxoplasmosis

Toxoplasmosis is a zoonosis caused by the protozoan Toxoplasma gondii. This globally distributed parasite has felids as the main host and small rodents as natural intermediate hosts. Disease occurs when abnormal hosts, for example sheep or swine, ingest the oocysts. Disease has been reported in lagomorphs and birds, and occasionally in other species. Concurrent immunosuppressive disease in man or animals is responsible for increased clinical prevalence.
Tyzzer's disease

Infection with the bacterium *Bacillus pilliformis* is termed Tyzzer's disease. This disease is manifest as an acute septicaemia in burrowing wild mammals such as muskrats (*Ondrata zibethicus*), rabbits and small rodents. Environmental contamination is the source of infection since the organism can remain in the soil for prolonged periods. Recurrent episodes of localised mortality have been observed in animals that associate with contaminated burrows. Animal to animal transmission is not an important epidemiologic feature of the disease.

2. Birds

Avian pox

Avian pox viruses cause proliferative lesions on the non-feathered skin and mucous membranes of the mouth, nares and eyes of birds. There are numerous strains of avian pox viruses, most of which are species specific. Mosquitoes are considered important virus transmitters but the agent can also be transmitted by mechanical scarification. Many infections are subclinical, but morbidity and mortality occur when proliferative lesions interfere with vision, respiration, or feeding. The disease is most frequently seen in small passerines, gallinaceous game birds, raptors and colonial-nesting marine birds. Avian pox can cause sporadic episodes of mortality.

Avian malaria

Avian malaria is caused by blood protozoan parasites of the genus *Plasmodium*, of which there are numerous species. The parasites are transmitted by mosquitoes which are both necessary intermediate hosts and vectors. Most species of *Plasmodium* are species or group specific for birds although cross-transmission occurs in some cases. Clinical disease is generally not observed; however, introduction of exotic bird species into Hawaii is thought to have been responsible for decimation of some native birds.

Heartworm of swans

*Sarconema eurycerba* is a filaroid nematode with adult worms infecting the hearts of anseriform birds, and especially whistling swans (*Cygnus cygnus*). The disease is reported from Europe and North America. The parasite causes coronary vascular occlusion with infarction and myocarditis. The parasite is transmitted by an arthropod vector. It causes significant mortality in whistling swans, but its presence in and impact on other anseriform birds is not known.

Histomoniasis

Histomoniasis is a disease of birds (notably galliformes) caused by the protozoan parasite, *Histomonas meleagridis*. This disease has a widespread distribution and affects turkeys, grouse, capercaille (*Tetrao*
Appendix VII (contd)

urogallus), chukars, partridges and quail. A recent outbreak occurred in swans. Some galliform birds are inapparent carriers. The disease is manifest as a necrotic typhlitis and hepatitis. The caecal nematodes, Heterakis spp., are known carriers of the protozoan. Histomoniasis has been identified as having potential significance to free-living wild turkeys and certain other galliformes.

Inclusion body hepatitis

Inclusion body hepatitis (IBH) of birds is a general term for a group of hepatic diseases caused by herpesviruses. Recognised disease occurs in diurnal birds of prey, owls, cranes, parrots (Pacheco's disease), pigeons, and some passerine and other species. The distribution of the different forms of the disease seems to be worldwide for some, while others are reported only from some species and regions. It is an acute septicaemic disease with high mortality. Chronic cases as well as carriers occur. IBH is believed to be transmitted directly, indirectly or by vectors. Most strains of IBH are species-specific but a few are cross-infective. IBH occurs both in the wild and in captive birds.

Trichomoniasis

This disease is caused by an obligate parasitic flagellate protozoan, Trichomonas gallinae. The parasite resides in the oral cavity and crops of numerous species of birds and some protozoan strains are more pathogenic than others. Disease is manifest as a caseous proliferative lesion in the oral cavity or crop which interferes with feeding or respiration. Doves and pigeons (Columbiforms) are frequently infected and can be subject to sporadic episodes of high mortality. Birds of prey (falcons, hawks, owls, etc.) can become secondarily infected by feeding upon infected smaller birds.
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Appendix VII (contd)

- lynx (*Lynx lynx*)
- moose, or European elk (*Alces alces*)
- mule deer (*Odocoileus hemionus*)
- musk ox (*Ovibos moschatus*)
- muskrat (*Ondatra zibethicus*)
- oryx (*Oryx gazella*)
- pronghorn antelope (*Antilocapra americana*)
- rabbit (*Oryctolagus cuniculus*)
- raccoon (*Procyon lotor*)
- raccoon dog (*Nyctereutes procyonoides*)
- red deer (*Cervus elaphus*)
- red fox (*Vulpes vulpes*)
- reindeer/caribou (*Rangifer tarandus*)
- roe deer (*Capreolus capreolus*)
- sea lion (*Zalophus californianus*)
- spotted skunk (*Spilogale putorius*)
- springbok (*Antidorcas marsupialis*)
- striped skunk (*Mephitis mephitis*)
- walrus (*Odobenus rosmarus*)
- warthog (*Phacochoerus aethiopicus*)
- water buffalo (*Bubalus bubalis*)
- whistling swan (*Cygnus cygnus*)
- white-tailed deer (*Odocoileus virginianus*)
- wild boar (*Sus scrofa*)
- wild dog (*Lycaon pictus*)
- wood bison (*Bison bison athabascae*)
- zebra (*Equus burchelli*)

- lynx boréal
- élan
- cerf mulet
- boeuf musqué
- rat musqué
- oryx gemsbok
- antillocapre nord-américaine
- lapin de garenne
- raton laveur
- chien viverrin
- cerf élaphe
- renard roux
- renne
- chevreuil
- mouffette tachetée
- mouffette rayée
- morse
- phacochère
- buffle domestique
- cygne chanteur
- cerf de Virginie
- sanglier
- lycan
- bison des bois
- zèbre de Burchell
Appendix VII

RELOCATION OF WILDLIFE:
IDENTIFYING AND EVALUATING DISEASE RISKS*

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Introduction

In his epic treatise, Leopold (1933) listed "artificial replenishment (restocking and game farming)" as the fourth of five stages in the sequential evolution of game management. In the context of wildlife management in North America, relocation of wildlife has been conducted primarily to: (1) restore native species in portions of their range where they had been extirpated, (2) supplement existing low density native population, (3) establish species in areas where they were not indigenous and (4) solve nuisance animal problems. In addition, wildlife has often been relocated to meet the objectives of scientific research, zoological collections or personal hobbies. Wildlife relocation has been the key component in the success of many earlier restoration and management programmes involving game species as exemplified by wild turkeys (*Meleagris gallopavo*) (Lewis 1987), white-tailed deer (*Odocoileus virginianus*) (Downing 1987) and ring-necked pheasants (*Phasianus colchicus*) (Dahlgren 1987). Contemporary wildlife programs continue to rely on relocation in both game and nongame management including, for example, the recovery of endangered species such as the red wolf (*Canis rufus*) (Phillips and Parker 1988), peregrine falcon (*Falco peregrinus*) (Barclay and Cade 1983) and red-cockaded woodpecker (*Picoides borealis*) (Odum *et al.* 1982, Odum 1983).

Beyond agency-sponsored wildlife relocation programs, wild species also are often relocated within the private sector. Private sector relocations include movement of both bona fide wild animals and release of game farm animals. Current examples are relocation of foxes and coyotes (*Canis latrans*) to stock fox-chasing enclosures (Clark and Widner 1987, Baker 1990, Poten 1991) and releases of pen-raised game birds such as bobwhites (*Colinus virginianus*) (Brennan 1991). However, relocations within the private sector, both sanctioned and unsanctioned, have come under increasing regulatory restrictions by wildlife agencies as potential problems with these activities have been identified.

Historically, minimal attention has been given to the potential disease implications of wildlife relocation, whether relocations occurred within the public or private sectors. Although some early authors mentioned

the possibility of disease introduction through wildlife relocation (Leopold 1933, Grange 1949, Allen 1954), literally millions of wild and pen-raised animals have been relocated and released without much, if any, attention to potential disease risks. In fairness, it must be acknowledged that for many years relatively little was known about pathogenic organisms among wildlife let alone accurate data on their prevalences, distributions, pathogenicities or host susceptibilities. Perhaps the most widely espoused warning with regard to disease risks has been the admonishment by turkey biologists that release of pen-raised turkeys constituted health risks to native wild populations (Bailey and Rinell 1968, Wunz 1971, Mosby 1973, Williams 1981). Based on the data available during the period, risk of disease appeared to have been used as a theoretical justification for discouraging a faulty restoration technique since disease problems were undocumented.

We have encountered the philosophy that, because large numbers of animals have been moved in the past without catastrophic high mortality epizootics, disease risks through relocation are not really significant. Some specific examples of disease problems closely linked to wildlife relocation clearly indicate that the spread of disease via the relocation of wildlife is of more than theoretical concern. A major problem with bovine tuberculosis and bovine brucellosis, which has existed for at least six decades in wood bison (Bison bison athabascae) in the Wood Buffalo National Park in Canada, has been attributed to the relocation of infected plains bison from the United States (Reynolds et al. 1982, Gainer 1982, Broughton 1983). The current, seven-state mid-Atlantic epizootic of rabies among raccoons (Procyon lotor) is strongly linked to translocation of raccoons (Nettles et al. 1979, Smith et al. 1984, Jenkins and Winkler 1987).

Contemporary wildlife scientists have come to recognize that the relocation of wild animals never consists of the movement of a single species. Rather, it always entails relocation of a "biological package" consisting of the animal itself (host) and its passenger organisms, potentially including viruses, bacteria, fungi, protozoans, helminths, arthropods or other pathogens.

The continuing relocation of wildlife, within both the public and private sectors, verifies that the potential for initiation of disease problems remains omnipresent. Specific examples from current wildlife relocation activities serve to illustrate the concerns. Recently, red foxes (Vulpes vulpes) from an interstate relocation attempt by private citizens were documented to harbor Echinococcus multilocularis, the tapeworm which causes aveolar hydatid disease in humans (Davidson et al. 1992). Numerous wild swine (Sus scrofa) populations are known to have pseudorabies and swine brucellosis (Zygmont et al. 1982, Nettles 1984, Corn et al. 1986, Pirtle et al. 1989, USDA 1991), yet these animals are often relocated without any provisions for disease prevention. The increased use of pen-raised mallards (Anas platyrhynchos) at regulated shooting areas has rekindled concerns (Hayes and Davidson 1978, Nettles and Thorne 1988) for the initiation of duck plague among wild waterfowl.

Methods
In response to the need to better evaluate potential disease risks that may be associated with wildlife relocation, including release of pen-raised stock, a prototypic disease risk assessment system was developed. The system has been utilized under actual relocation scenarios to assess the potential disease risks of relocating wild caught raccoons, foxes and coyotes, as well as the disease risks of releasing pen-raised turkeys and bobwhites.

Origin and Development of the System

During the 1970s, many southeastern state wildlife agencies were faced with the large-scale purchase, importation and release of raccoons by private raccoon clubs. The legality of this activity varied among states; however, a common denominator was that major sources of supply were private animal dealers in Florida and Texas. At the time, Florida and southern portions of Georgia were recognized as the only focus of raccoon rabies in the United States (Prather et al. 1975). Wildlife agencies had various concerns regarding this practice, but one of primary importance was the potential for introduction of raccoon rabies. Rabies often was used as justification for prohibition of raccoon importation. However, conclusive data to substantiate this risk, such as actual demonstration of rabies in translocated raccoons, was not available. The lack of data on disease risks associated with raccoon importation complicated defense of state wildlife agencies' policies prohibiting this activity.

In 1976, the Tennessee Wildlife Resources Agency confiscated a shipment of 100 raccoons illegally imported from Florida. Tennessee requested that the Southeastern Cooperative Wildlife Disease Study (SCWDS) examine them for rabies and other important diseases. This action provided the first opportunity to gather data on the pathogens that were actually present among raccoons being translocated. The necropsy and testing protocols used on this group of raccoons were based on existing literature regarding parasites and diseases of raccoons and were designed to detect most previously reported pathogens. Following this initial work, a research effort was initiated to develop disease and parasite profiles of translocated raccoons and to use these data to assess disease risks that might be associated with raccoon translocation.
Description of the System for Raccoons

A decision was made to devise a comprehensive health evaluation protocol not limited to rabies. Furthermore, the procedures for pathogen detection were devised to disclose not only organisms important to the health of raccoons, but also to include those important among other wildlife, domestic livestock, pets and humans. The risk assessment included evaluation of the potential for two distinct disease scenarios. The most obvious was the possibility that an "exotic" pathogen could be introduced and become established in a new geographic area. A second possibility was that the release of infected raccoons could cause an artificial intensification of an enzootic or pre-existing disease (Schaffer 1979, Schaffer et al. 1981).

The rationale for evaluation of the risk posed by the organisms detected consisted of a two-tiered process (Schaffer 1979, Schaffer et al. 1981). The first step in the process was an evaluation of the ability of the organism to persist at release sites. This was accomplished by determination of the epizootiologic requirements of the disease or parasite as reported in the literature. Organisms were believed to be more likely to become established at release sites if they (1) had a widespread geographic distribution, (2) had a direct transmission cycle or a widespread distribution of vectors/intermediate hosts, (3) had a high prevalence and intensity of infection in translocated raccoons and (4) were infective for other species of animals at release sites. A subjective four category scale was devised to rate the probability of establishment. The categories were: (1) excellent, for those known to already be enzootic at release sites; (2) possible, for those with direct transmission or those with vectors/intermediate hosts known to be present on release sites; (3) improbable, for those requiring specific vectors/intermediate hosts not present at release sites; and (4) unknown, for those with unknown epizootiology.

The second step in the process was an assessment of the pathology capabilities of the various organisms with raccoons, other wildlife species, domestic animals and humans, based on reports in the scientific literature. The categories for this assessment were: (1) pathogenic, for those known to produce disease; (2) non-pathogenic, for those studied well enough to determine that they never produce illness; and (3) unknown, for those with insufficient study to evaluate pathogenicity (Schaffer 1979, Schaffer et al. 1981).

Ultimate assessment of the risk posed by each pathogen was then based on a combination of its establishment and pathogenicity rating. Pathogens with either a low probability of establishment or a lack of pathogenicity were considered to pose little risk. Conversely, those which exhibited both a reasonable probability of establishment and pathogenicity in raccoons or other hosts were considered to pose a significant risk. Risk could not be predicted for those with an unknown ranking. Finally, it was noted that the risk assessments were not absolutely predictable and that biological factors in the release areas might favour exotic pathogens normally considered harmless, thereby producing unforeseen disease syndromes.

Results and Discussion

Past Applications of the System
As noted above, the first use of the system was to gain a more in-depth understanding of the disease risks posed by private sector raccoon translocation. This was accomplished through study of additional translocated raccoons that were either seized by state wildlife agencies or anonymously purchased from suppliers. These studies disclosed potential risks from hematotropic protozoan parasites (Schaffer et al. 1978), helminth parasites (Schaffer et al. 1981), Salmonella and Leptospira infections (SCWDS unpublished data), rabies (Nettles et al. 1979), canine distemper (SCWDS unpublished data), and parvovirus infections (Nettles et al. 1980). Collectively, these findings, in conjunction with the manner of private sector transport of raccoons (Nettles and Martin 1978), clearly showed that indiscriminate translocation of wild raccoons was biologically hazardous. Unfortunately, the dangerous consequences of this practice were rather quickly confirmed by an epizootic of raccoon rabies in the mid-Atlantic states. The detection of rabid animals in translocated raccoons (Nettles and Martin 1978, Nettles et al. 1979), combined with monoclonal antibody studies demonstrating
mid-Atlantic rabies virus isolates to be indistinguishable from those in the original Florida epizootic (Smith et al. 1984), provide convincing evidence that the epizootic originated from the relocation of rabid raccoons (Jenkins and Winkler 1987).

Schorr et al. (1988) subsequently utilized this same disease risk assessment system to evaluate the disease status of pen-raised wild turkeys. Diseases of major concern identified were histomoniasis ("blackhead disease"), syngamiasis, avian pox, mycoplasmosis and salmonellosis. Schorr et al. (1988) concluded that these diseases were threats to wild and domestic turkeys and urged that "release of pen-raised wild turkeys be discouraged, if not prohibited". SCWDS (unpublished data) also has provided disease risk assessments on groups of pen-raised bobwhites presented to state wildlife agencies for release to conduct bird dog field trials. Organisms of concern in some of these groups included avian pox virus, Histomonas meleagridis and Heterakis gallinarum (vector of histomoniasis). Avian pox and histomoniasis previously had been assigned a "high risk" rating from release of pen-raised bobwhites (Davidson et al. 1982).

The latest application of the system was with private sector importation of red foxes and coyotes from the midwestern United States to stock fox chasing enclosures in the Southeast (Davidson et al. 1992). This study of confiscated, illegally imported foxes and coyotes disclosed infections of Echinococcus multilocularis, the etiologic agent of alveolar hydatid disease in humans, among the red foxes. The finding was judged to constitute a significant risk since this zoonotic tapeworm does not occur in the Southeast. Its introduction and spread on several Japanese islands has been linked to development of a fox ranching industry (Inukai et al. 1955, Rausch 1956, 1986) and its occurrence in the upper Midwest and adjacent Canadian provinces is believed to have been due to movement of canid definitive hosts from the Arctic by man (Wilson and Rausch 1980, Rausch 1986).

Finally, on two occasions, we have utilized existing information from the scientific literature to apply the basic concepts of this process to estimate disease risks without actual examination of animals. In one instance, potential disease risks of a proposed snowshoe hare (Lepus americanus) relocation program were categorized for a state wildlife agency (McKenzie and Nettles 1981). The second involved a preliminary evaluation of the potential disease problems that might be associated with release of pen-raised waterfowl for hunting purposes (SCWDS unpublished files).

Overview and Recommendations

The disease risk evaluation system described provides a conceptual approach for identifying and subjectively categorizing risks rather than providing a means of specifically quantifying them. Nevertheless, it has provided information valuable to wildlife agencies in both the development and defense of policies on the translocation of certain species. Although the operational performance of the system has not been validated by experimental study, the raccoon rabies episode exemplifies its ability to identify risks, albeit by virtue of the rabies epizootic.
Applications to date have involved assessments of animal relocation activities that already were underway. In the future, a proactive application before animals are relocated would be preferable, since this would afford an opportunity to identify and possibly prevent potential problems. In this regard, development of specific guidelines for disease testing would be helpful for those species which are relocated frequently and in large numbers. An example would be the Wildlife Disease Association's disease monitoring guidelines for wild turkey relocation programs (Amundson 1985, Wildlife Disease Association 1985).

However, there are problems that need to be overcome to provide adequate and timely health evaluation services to ensure avoidance of disease problems from relocation of wildlife. One obvious problem is the availability of sufficient diagnostic and laboratory support to provide the disease evaluation services. Although there are several agency and university laboratories staffed with personnel specializing in wildlife diseases, we doubt that they have the resources to provide these services in every relocation situation where they are indicated. Augmentation of resources in this area should receive more attention.

Another problem is inadequate data on the geographic distribution, host susceptibilities and pathogenic capabilities of pathogens among many wildlife populations. Basic information on these subjects is an integral part of the evaluation system described, and without this foundation, one is forced to start from "ground zero". In contrast, with sufficient baseline data, the disease risk evaluations can be done entirely "on paper" without the need for examining animals. For example, enough is known on the life cycle, distribution, prevalence and pathogenicity of the white-tailed deer meningeal worm (*Parelaphostrongylus tenuis*) which causes fatal neurologic disease in other native cervids and certain exotic ungulates (Anderson and Prestwood 1981), to accurately evaluate the risk of parelaphostrongylosis from white-tailed deer relocation programs. Therefore, we should alter our tendency to categorize parasite and disease projects as "just another survey" or "just another pathologic description" and view them in the holistic context of contributing to disease prevention programs.

Finally, although this discussion has focused on the potential for initiation or spread of disease by relocation of animals and their passenger pathogens, its antithesis also exists. In this case, the principal concern is not for initiation of disease problems originating from the relocated animal, but rather whether the relocated animal will contract enzootic diseases at the release site. This scenario is particularly important with highly valuable animals such as endangered species, but it also can be a factor in the success of any wildlife relocation program. For example, eastern woodrats (*Neotoma floridana*) became infected with *Baylisascaris procyonis*, a neurotropic roundworm of raccoons, and developed neurologic disease following release in former range in New York where *B. procyonis* occurs (W.B. Stone, personal communication: 1992). Introductions of elk (*Cervus canadensis*), caribou (*Rangifer tarandus*), black-tailed deer (*O. hemionus columbianus*) and moose (*Alces alces*) in the eastern United States all have had problems to some extent with neurologic disease caused by the white-tailed deer meningeal worm, which is enzootic in much of eastern North America (Anderson and Prestwood 1981). The procedures described can be reversed to evaluate the risk of diseases occurring at release sites to relocated animals.
In order to integrate the described or a similar disease risk evaluation component into wildlife relocation activities, we provide the following recommendations:

1. consider disease potentials before initiating an agency sponsored relocation program or before allowing wildlife relocation by the private sector;

2. as a minimum, incorporate a literature review to identify potential disease risks;

3. presample the source population for those pathogens identified as potential problems; and

4. necropsy and/or test a subsample of individuals being relocated.

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References


Appendix VIII (contd.)


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Appendix VIII (contd)


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