The health of the wild red deer of Exmoor
And an assessment of their role in the transmission of disease to livestock and humans

A report to the Exmoor National Park Authority

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Appendix 1
Cases of laboratory confirmed bTB on Exmoor April 2000 to September 2008
1) Introduction

In common with wild red deer in other parts of England, the red deer herd on Exmoor is generally regarded as healthy [Chapman, 1991], although health may suffer when populations outgrow the available food supply and climatic conditions are poor [Clutton-Brock et al., 1982]. On Exmoor however, food is normally plentiful and climatic conditions benign.

Close examination reveals that red deer across Europe are commonly infected with internal parasites [Bohm et al., 2006; Rehbein et al., 2002]. Red deer may carry or succumb to other infections on occasions and it is known that deer can play a role in the epidemiology of a wide range of livestock and human diseases [Simpson, 2002]. However, the degree of risk associated with red deer on Exmoor and instances of disease transmission are less well documented.

Wild deer are usually relatively free from clinical disease, although they may be subclinically infected with a variety of parasites, bacteria and viruses. Many of these infectious agents are not specific to deer and there are disease relationships with other animals, wild and domestic, with which they may have contact. [Mackintosh & Beatson, 1985; Bohm et al., 2007]. However, there are sufficient differentials for farmed deer management to be often integrated with management of cattle in order to optimise the differences in susceptibility to parasites between the species. Pasture rotation is employed to provide 'safe' pasture for young stock of alternate species, a system facilitated by the differences in breeding dates and energy requirements [Van Reenen & Innes, 1985]

The possible role of wild deer as a source of infection for livestock and humans in the UK has recently been reviewed by Bohm et al [2007]. A similar review of deer as hosts or transmitters of pathogens in the USA was published twelve years earlier by Alonso-Aguirre et al. [1995]. A review of mutual transmission of disease between wildlife and livestock in Europe was published by Froliche et al. [2002]. The following review focuses upon potential pathogens to which Exmoor deer may be susceptible or which they may harbour without ill effect.
2] A review of potential pathogens in Exmoor red deer

2.1.] BACTERIAL DISEASES

2.1.1.] Bovine TB \((\text{Mycobacterium bovis})\)

Bovine TB can infect many mammals as well as cattle, including red deer, and also humans. It is widely accepted that badgers constitute the most important reservoir of TB in wildlife in the UK and there is no evidence of a significant self-maintaining reservoir of infection in any other wild mammal [Delahay et al., 2007]. The occurrence of bovine TB in deer has been linked to its presence in badgers and also to areas of very high deer population densities [Bohm et al., 2007; Hickling, 2002]. TB in UK deer may also be caused by infection with avian TB, \(\text{Mycobacterium avium}\). [Delahay et al., 2002]

TB is mainly transmitted via the respiratory route or the faecal-oral route between animals. In humans, pasteurisation of milk has rendered the digestive route of infection from cattle unimportant, but people working in close contact with infected animals may be susceptible to airborne transmission [Bohm et al., 2007]. It is believed that infected deer pose only a very limited risk to human health but may constitute a greater risk to other wildlife, particularly foxes and badgers, which may feed on infected carcases [Defra, 2006]. There is evidence that infected white tailed deer in the USA play a part in the epidemiology of TB on cattle farms [Kaneene et al., 2002]. It has been suggested that their relatively high rate of bacterial excretion allows deer to potentially transmit bovine TB to cattle, especially where the population density is high. However, they are unlikely to do so often, since they seldom interact closely with cattle [Delahay et al. 2007] and are believed to generally avoid them [Defra, 2006].

Wild deer are believed to act as spillover hosts to bovine TB across much of south-west England. Infection of bTB in deer in the South West is generally estimated to be at less than 1% [Paterson 2008], and in red deer specifically at an average of 1.2% [Ward et al. 2008] although in a few areas high densities may have elevated them to the potential for maintenance host status. Ward et al [2008] suggest that some localised populations, particularly on Exmoor and the Quantock Hills, are known to roam in large herds, which could potentially elevate them to maintenance host status if they become infected with \(\text{M. bovis}\).

Whilst this represents a degree of disease transmission risk to cattle, the level of per capita risk is likely to be lower than that posed by badgers as the most important maintenance host, and the likely source of infection for the deer. If disease prevalence in badgers can be reduced, disease prevalence should reduce amongst deer. It is likely that efforts to reduce risks to cattle posed by deer would yield only limited benefits if infection in badgers was not addressed [Defra 2006] However, where large herds containing infected red deer persist, population reduction could reduce them below the host status threshold. [Ward et al 2008].

It appears that in low to moderate densities, deer populations normally act as spillover hosts. Maintenance of TB infection can probably only prevail in areas of exceptionally high deer density, such as on deer farms or where wild deer congregate for feeding [Vincente et al., 2007a; Griffin et al., 2000 and 2004, as reported in Defra, 2006]. If so, it is likely that reducing locally high population densities may be an effective control measure. Large aggregations of deer feeding together in small areas should be discouraged through limiting access to artificial food sources [Defra, 2006]. It has been demonstrated that \(\text{M. bovis}\) bacteria can survive on feedstuffs for many days, depending on temperature, but for at least a week at all temperatures [Palmer & Whipple, 2006]. Deer-to-deer transmission on feed has been proven by Palmer et al., [2004]. They
recommended that the intentional or unintentional provision of artificial feed to deer should be avoided because both direct and indirect transmission of *M bovis* are enhanced. In the north-east states of the USA, a serious bTB outbreak has been documented in white-tailed deer where high densities of deer built up when artificial feeding was undertaken by hunting clubs. Deer became the primary reservoir host and were implicated in the disease spreading to cattle. Prohibition of deliberate artificial feeding of white tailed deer was a key element of a successful bTB control strategy [Hickling, 2002; O’Brien et al., 2002].

### 2.1.2 Johne’s Disease (*Mycobacterium avium* subspecies *paratuberculosis*)

Johne’s disease is a chronic wasting disease of the intestines leading to severe ill-thrift and death, primarily affecting ruminants. In deer, the lesions may resemble those caused by bTB, but deer differ from cattle in that juveniles may be clinically affected and chronic wasting may occur without diarrhoea [Reid, 1994a]. The bacterium is passed out in faeces where it contaminates pasture and water and can be passed from hind to calf in milk. No immediate symptoms may be apparent, but can develop later during periods of stress. Many animals may remain sub-clinical carriers all their lives [Mackintosh, 2002; CALU, 2006].

Young animals, especially neonates, are most susceptible to initial infection and these animals are most likely to develop clinical signs in later life; infection acquired by adult cattle and sheep is more likely to result in permanent carrier status without disease [Haig & Hudson, 1993]. Sheep and beef systems where animals lamb and calve outdoors are therefore at greatest risk. There are believed to be links through the food chain with Crohn’s disease in humans [Bohm et al. 2007].

Cattle, sheep, deer and other wild animals are susceptible to Johne’s disease. There are several different strains of the disease and, in general, most sheep strains do not become established in cattle and *vice versa*. It is not clear to what extent wildlife may act as reservoirs for the disease, or have a role in disseminating infection [Sargison, 2003].

Infection is generally transmitted via the faecal-oral route, through ingestion of contaminated faeces. In domestic animals, transmission of Johne’s disease is enhanced by high stocking rates with resultant increased exposure of susceptible calves to contaminated faeces. Equivalent risk factors of high deer density, low nutritional quality of pasture and over-concentration of deer at artificial feeding sites were present in Key deer populations in Florida, U.S.A. when clinical *M. avium subsp. paratuberculosis* was diagnosed [Quist et al., 2002].

### 2.1.3 Yersiniosis

This disease, caused by the bacteria of the genus *Yersinia* is a serious disease of farmed deer. Two species of the organism may cause disease: *Y. pseudotuberculosis* is the most serious pathogen, although *Y. enterocolitica* occasionally causes clinical signs. It occurs predominantly in young animals in winter and is related to stress; often precipitated by high densities, adverse weather conditions and nutritional stress. It takes the form of an acute haemorrhagic gastroenteritis with severe scour, resulting in death within two days [Reid, 1994a; Haig & Hudson, 1993]. Apart from deer, many other wild mammals and birds are susceptible and the pathogen is a serious cause of morbidity in zoological collections [Siemering, 1986], but it is not known whether wild deer are significant reservoirs of yersiniosis [Mackintosh & Henderson, 1985; Mackintosh, 1988, Simpson, 2002].
Yersiniosis in humans is mostly caused by *Yersinia enterocolitica*, which may be present as a subclinical infection in deer, and usually contracted by consuming contaminated food or water. The disease is a zoonoses but relationships between human and animal infections are complex. [Defra, 2007].

2.1.4.] Leptospirosis

Leptospirosis is a bacterial disease caused by infection with *Leptospira*, which persist in the kidneys and genital tracts of carrier animals and are shed in the urine and genital fluids. Several species and serovars cause a variety of diseases in many mammals including Weil's Disease in humans [serovar *Icterohaemorrhagiae*] and fatal leptospirosis of dogs [serovar *Canicola*]. Humans may contract the disease through contact with infected animal urine, possibly through swimming or canoeing in fresh water or working with livestock. The principal host of these two serovars is the brown rat, although badgers may also carry the infections [Simpson, 2002]. Cattle and pigs may carry other serovars, and leptospirosis of cattle, caused by serovar *Hardjo*, has been a major cause of infertility. There has been a decline in leptospirosis in cattle in recent years, associated with vaccination [Defra, 2007].

In New Zealand there have been outbreaks of leptospirosis in farmed deer and also in people working with those deer; usually slaughterhouse workers. [Ayanegui-Alcerreca et al., 2007]. However, a serological study of various strains of the infection in free-living deer in the UK concluded that there is a very low incidence and deer are not significant as reservoir hosts [Twigg et al., 1973, as reported in Simpson, 2002]. In the western states of the USA, no evidence of exposure to *Leptospira* was detected in nearly 600 wild deer sampled and tested for the pathogens [Alonso-Aguirre et al., 1995].

2.1.5.] Salmonellosis

*Salmonella*ae of various species and serotypes cause disease in humans and animals in all parts of the world [Haigh & Hudson, 1993] and infection is by the faeco-oral route. In common with many ruminants, red deer may both harbour and succumb to salmonellosis, especially as neonates [McCallum et al., 1978]. In the UK, salmonellosis in farmed deer is uncommon and appears to be precipitated by poor management [Reid, 1994b]. There are no reports of salmonellosis causing disease in wild deer in the UK.

2.1.6.] Coliform enterocolitis

*Escherichia coli* is a bacterial organism that is a normal inhabitant of the gastrointestinal tract of all animals. It has numerous non-pathogenic serotypes and several pathogenic serotypes, which predominantly cause enteritis or colitis and may affect red deer [Haig & Hudson, 1993]. One particular serotype, Verocytotoxice E. coli O157, causes severe and even fatal disease in humans. At least 45% of UK cattle farms harbour this serotype and the advice from The Veterinary Laboratory Agency and the UK Health and Safety Executive is that all ruminant animals should be considered to be carriers [VLA, 2003: HSE, 2002], although there is no evidence of clinical disease in wild deer in the UK.

2.1.7.] Lyme Disease *Borreliosis*

Lyme disease, caused by *Borrelia burgdorferi* is the most common tick-borne human disease in the northern hemisphere, and can also affect dogs, cats and horses. The reservoir hosts for the pathogen are small mammals, particularly mice and voles, upon which the juvenile nymphal stages of the ticks feed [White, 1998]. Most human patients with Lyme Disease have contracted the infection from the bite of an immature tick that in turn acquired the infection from a small rodent. Deer are not competent hosts for the
disease but are significant in the epidemiology of borreliosis, as they act as hosts for adult breeding ticks and, in common with birds, disperse the tick vectors. They may therefore amplify infection [Bohm et al., 2007; Simpson 2002].

2.1.8. Tick-Borne Fever [Anaplasmosis]

Tick-borne fever [TBF], an important disease of sheep, is caused by the organism *Anaplasma phagocytophilum* [recently reclassified and formerly known as *Ehrlichia phagocytophilum*]. The infection is transmitted by ticks. It is considered to be the single most important cause of sheep mortality in upland flocks causing abortion, predisposing to *Staphylococcal pyaemia* and other diseases [Brodie et al., 1986, University of Reading, 2000]. The pathogen also causes disease in humans, dogs and horses; DNA analysis of *A. phagocytophilum* recovered from red deer in central Europe showed that one strain carried by the deer was indistinguishable from the strain causing human disease [Zeman & Pecha, 2008]. White tailed deer can be infected with the human strain of the organism and remain as carriers without showing any clinical signs [Tate et al., 2005], whereas disease has been reported in roe deer [Stuen et al., 2006].

Deer can be naturally infected with TBF; although Bohm et al. [2007] question the role of deer in the epidemiology of TBF, other work suggests that wild red deer may be acting as carriers of the organism in Europe and the UK [Hartlet, et al., 2004; Zeman & Pecha 2008, R Birtles personal communication.]

2.2] VIRAL DISEASES

2.2.1.] Bovine viral diarrhoea (BVD)

BVD is economically important due to its effects on cattle and sheep reproduction. It causes abortion, infertility, pneumonia, diarrhoea and poor growth. Indeed, it causes such a wide range of disease that it is rare to be able to diagnose the cause on clinical signs alone. [Laven, 2001].

It is unclear whether wild deer may act as a reservoir for infection but direct contact between infected livestock and susceptible wildlife has been postulated as a source of BVD in wildlife. Bohm et al. [2007] state that the clinical signs known from bovine infection have never been observed in farmed or wild deer. Wild European deer of all species are widely seropositive and have evidence of persistent infection, indicating exposure to BVD virus according to Van Campen et al. [2001], but they cite no confirmed outbreaks of clinical disease in deer. Simpson [2002] states that BVD has been found in red deer, which may reflect the same view.

2.2.2.] Malignant Catarrhal Fever (MCF)

MCF affects cattle and deer as well as some other animals. The disease is caused by one of two Herpes viruses: AHV1 occurs naturally in wildebeest and OHV1 occurs naturally in domestic sheep. Neither virus produces clinical signs of disease in its natural host but gives rise to severe disease if transmission occurs to deer, cattle or giraffes [Heuschele & Reid, 2001]. Both cattle and deer suffer severe illness, often resulting in death, though both appear to be a dead-end hosts for the virus and infection does not usually spread between them [Laven, 2003; University of Reading, 2000]
MCF is important and increasing amongst farmed deer. The disease is spread by sheep, especially ewes at and around lambing, which can excrete the virus whilst showing no clinical signs of the disease. [CALU, 2006]. Transmission is mainly respiratory and any infection in wild deer, probably stems from direct or indirect contact with infected sheep due to shared grazing [Bohm et al., 2007]. There is great variation in susceptibility to infection among deer species, with Pere David’s deer being the most susceptible and red deer being much more susceptible than domestic cattle, while fallow deer are thought to be resistant [Reid, 1994c]. However, deer cannot pass on the disease to sheep, cattle or other deer.

2.2.3. Infectious bovine rhinotracheitis [IBR]

A serological study of free-living deer in the UK found that 16% of red deer had antibody to bovine herpesvirus, the cause of infectious bovine rhinotracheitis [IBR] in cattle. [Lawman et al., 1978, as reported in Simpson 2002] However, red deer are more commonly infected with a second type of herpesvirus that can cause mild ocular disease in deer under stress, but not in cattle, and deer cannot be experimentally infected with virulent cattle IBR. [Castro, 2001; Nettleton et al., 1988, as reported in Simpson, 2002].

2.2.4. Transmissible Spongiform Encephalopathies (TSEs)

These diseases include BSE (Bovine Spongiform Encephalopathy), scrapie and CWD (Chronic Wasting Disease), and are of particular concern because of the link between BSE and vCJD in humans. CWD has been found in deer in the USA and Canada, with no known links to human disease. No TSE’s have been shown to occur naturally in deer in the U.K. [Williams et al., 2001].

2.2.5. Louping ill

Louping Ill is a tick-borne viral neurological disease of sheep, which occasionally infects humans. It is one of a closely related family of viruses that includes West Nile virus and tick-borne encephalitis, the latter causing widespread severe disease in central and eastern Europe and Scandinavia, with up to 300 cases a year in Austria and Hungary [Nuttal & Labuda, 1998] The antibody has been detected in up to 30% of wild deer in Scotland. However, species other than sheep and red grouse, which both suffer significant mortality, appear to remain clinically healthy [Adam et al., 1977], although disease has been reported in red deer in captivity [Simpson, 2002]. It remains unclear whether deer are a competent host for the disease. [Bohm et al., 2007].

2.3. PROTOZOAL DISEASES

2.3.1. Redwater Fever [Babesiosis]

This disease is caused by a single cell parasite of the genus Babesia spread by ticks. There is a significant impact on productivity and fertility in affected cattle; acute cases are depressed, feverish and suffer disruption of the red blood cells with resultant haemoglobin pigment in the urine. It generally occurs in animals recently moved to pastures harbouring ticks [Laven, 2002]. Although deer may have separate species of Babesia, the species causing disease in cattle, B divergens, is known to occur in red deer, although clinical disease has not been reported [Adams et al., 1977; Hartelt et al., 2004; Munro, 1994; R. Birtles, personal communication.]. Animals well established in an area develop immunity and it is believed that deer generally do so successfully [J. Fletcher, personal communication].
2.3.2] Toxoplasmosis

The coccidial protozoan *Toxoplasma gondii* causes abortion and infertility in sheep and is an important zoonosis in humans, especially pregnant women. Red deer can carry the infection but appear to be only rarely affected by the pathogen, which is parasitic in many animals worldwide. The definitive host is the domestic cat, from which infection is usually contracted. The cat is the only host in which the parasite completes its life cycle and cats are the only animals to excrete infectious oocysts in their faeces. A minor route of infection may be from eating undercooked infected meat, including venison [Dubey, 1998].

2.3.3] Coccidiosis and Cryptosporidiosis

These protozoal diseases are significant causes of loss in calves, lambs and farmed deer calves. There are no reports of disease in wild red deer, but as the organisms are carried by almost all ruminants it is likely that unnaturally high population densities might give rise to disease in wild deer calves, especially if they are grazing with juvenile cattle [Angus, 1994, Haigh & Hudson, 1993].

2.4 PARASITIC DISEASES

2.4.1] INTERNAL PARASITES

2.4.1.1] Gastro–intestinal worms

A number of internal parasites of domestic livestock may infect red deer. Generally speaking, deer carry fewer nematode bowel worms than cattle or sheep and succumb to the effects of these worms at lower levels of infection than domestic stock [Haig & Hudson, 1993; Munro 1994]. The region of the gut most heavily infected in deer appears to be the abomasums, where *Ostertagia* spp. may cause serious disease [Munro, 1994]. A study on the Isle of Rum examined impacts of parasites on red deer and found abomasal nematodes in 100% of animals examined, of which the most abundant were the *Ostertagia* spp. Despite only low levels of infection, adult deer (though not calves) of both sexes showed significant decreased body condition with increased rates of infection. There was no impact on pregnancy rates. [Irvine *et al.*, 2006].

The following table summarises the pathogenic internal parasites of domestic stock, representatives of which have been recovered from red deer [from Simpson, 2002].

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Domestic species</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Haemonchus contortus</em></td>
<td>Cattle, sheep, goats</td>
<td>Haemonchosis: anaemia</td>
</tr>
<tr>
<td><em>Trichostrongylus axei</em></td>
<td>Cattle, sheep, goats, horses</td>
<td>Parasitic gastitis</td>
</tr>
<tr>
<td><em>Trichostrongylus sp.</em></td>
<td>Cattle, sheep, goats</td>
<td>Parasitic enteritis</td>
</tr>
<tr>
<td><em>Ostertagia sp.</em></td>
<td>Cattle, sheep, goats</td>
<td>Parasitic gastritis</td>
</tr>
<tr>
<td><em>Cooperia sp.</em></td>
<td>Cattle, sheep, goats</td>
<td>Parasitic enteritis</td>
</tr>
<tr>
<td><em>Nematodirus sp.</em></td>
<td>Sheep</td>
<td>Parasitic enteritis</td>
</tr>
<tr>
<td><em>Dictocaulus viviparus/eckerti</em></td>
<td>Cattle</td>
<td>Parasitic pneumonia</td>
</tr>
<tr>
<td><em>Prostostrongylus rufescens</em></td>
<td>Sheep, goats</td>
<td>Parasitic pneumonia</td>
</tr>
<tr>
<td><em>Elaphostrongylus sp.</em></td>
<td>Sheep, goats, calves</td>
<td>Parasitic pneumonia</td>
</tr>
<tr>
<td><em>Fasciola hepatica</em></td>
<td>Cattle, sheep, goats</td>
<td>Fascioliosis – liver fluke</td>
</tr>
<tr>
<td><em>Dicrocoelium dendriticum</em></td>
<td>Cattle, sheep, goats</td>
<td>Fascioliosis – liver fluke</td>
</tr>
</tbody>
</table>
2.4.1.2.] Lung Worms

Dictyocaulus spp. are the most common type of lungworm in deer and cause pathological changes in the lungs. Studies have found them to be present in 15% of red deer in Scotland, but in 80% of red deer in Germany. [Bohm et al., 2006 and 2007; Rehbein et al., 2002]. The differences may reflect both habitat and co-grazing with cattle. The lungworm Dictyocaulus viviparous causes husk in cattle, which they pick up by eating forage contaminated with infective larvae. The larvae migrate from the gut to the lungs, causing coughing and breathing difficulties [Laven, 2005]. However, deer rarely exhibit the ‘husk’ bronchitis symptoms seen in cattle, although they may rapidly lose condition and reduce food intake [Haigh & Hudson, 1993; Munro, 1994; Watson & Charleston, 1985].

A serious outbreak of husk occurred in dairy heifers turned out onto a new ley being grazed by wild red deer [Simpson, 2002], and cross species transmission between deer and cattle has been demonstrated. [Bohm et al., 2007].

A study in Scotland found that cattle infected with Dictyocaulus viviparus larvae derived from red deer suffered milder, though similar, symptoms than those infected with Dictyocaulus viviparus larvae derived from cattle. Researchers believed that these represented different strains of the species, and concluded that hazards to livestock health from infection where cattle and deer graze alternately could be acceptable. [Corrigall et al. 1988] The greater severity of the disease in cattle and the often asymptomatic state of infections in deer may be because the nematode evolved as a deer parasite. However, there do appear to be host-adapted strains of Dictyocaulus in deer and cattle [Watson & Charleston, 1985].

Elaphostrongylus cervi are tissue worms, the eggs and first stage larvae of which inhabit the lungs of red deer, causing congestion, consolidation, haemorrhage and pneumonia. [Watson & Charleston, 1985]. It has been found in 82% of red deer in Scotland, with older animals having a higher level of infection [Bohm et al., 2006].

A study to investigate the interaction between body condition and intensity of infection with the nematode Elaphostrongylus cervi found that spleen mass was positively related to body condition and negatively related to parasite infection. In stags only, body condition deteriorated as parasite count increased [Vincente, 2007b].

2.4.1.3.] Liver Fluke

Liver fluke disease is caused by the parasite Fasciola hepatica, which has a two-host life cycle involving snails and a variety of mammalian species including sheep, cattle, deer and rabbits. The seasonal appearance of the disease is determined by the effects of moisture and temperature on the snail populations and free-living stages of F. hepatica. Sub-acute disease is caused by massive liver damage due to the presence of migrating immature flukes [Sargison, 2003].

Where the infection is endemic, wild deer can act as a reservoir of infection for domestic animals sharing the same pasture. The variation in feeding habits reflect the incidence of infestation and browsing deer, such as roe deer, are less often affected; grazing deer like fallow deer and red deer are more commonly affected [Munro, 1994; Watson & Charleston, 1985].

Climate change is believed to be causing an increase in the incidence of this disease through creating optimal conditions for snails, i.e. milder, wetter weather [Bohm et al., 2007; VLA seasonal predictions 2008].
2.4.2] EXTERNAL PARASITES

2.4.2.1] Ticks

Ticks are blood-sucking arthropod parasites which, in large numbers, can cause unthriftness and anaemia. Suppurating wounds can result from their bites. However, the main concern is the diseases they carry and transmit to both livestock and humans. [Miller & West, 1972]. They probably act as vectors for more diseases than any other invertebrate host. The incidence of tick-borne diseases is in part related to tick abundance, and it is thought that the number and distribution of ticks is partly influenced by the density and movement of deer, as well as other host animals [Game & Wildlife Conservation Trust, 2008]. However, other influencing factors should also be considered, such as the composition, structure and management of vegetation, the weather and climate change (as ticks are susceptible to temperature and moisture stress). Additionally, social factors may influence the likelihood of people coming into contact with ticks or recognising that their illness is tick-related [Randolph, 2004].

A recent survey found that the distribution of ticks has expanded by 17% in recent years and that there are believed to be increasing numbers of ticks at 73% of locations throughout Britain. Data shows increased tick infestations on deer at 77% of MoD estates. In many places both tick numbers and deer numbers have increased at the same time, raising the possibility of a causal link. Although in other places, tick numbers appear to have increased despite a decline in deer numbers [Scharlemann et al., 2008; Game & Wildlife Conservation Trust, 2008]

If sheep are present as hosts then treating them with acaricide, so that they act as ‘tick mops’ may influence tick numbers in their environment. It is believed that effectively treated sheep can exert an influence to reduce tick numbers, even in the presence of low numbers of alternative hosts, such as deer. This is effective where deer numbers are lower than 5 per 100 hectares. However, high densities of red deer at 10 per 100 ha, may prevent them from doing so. [Smith, 2005a; Game & Wildlife Conservation Trust, 2008] On Exmoor, deer densities have been estimated at around three per square kilometre in the National Park as a whole, i.e. 3 per 100 ha [Langbein, 1997]. However, there are clearly areas within the National Park where the densities would, locally, be much higher.

Research work in Italy and the USA has demonstrated the significance of host species (rodents) of larval stage ticks in tick-borne pathogen transmission. Since deer carry high tick numbers, perpetuating tick populations, but do not support tick-borne pathogen transmission, they act as dilution transmission hosts. The localised absence of deer (loss of a dilution host) increases tick feeding on rodents, leading to potential tick-borne disease hotspots [Perkins et al., 2006; Pugliese & Rosa, 2008]. This might have significance on Exmoor in small deer exclusion areas, such as new woodland plantings or areas which deer avoid.

It has been demonstrated that tick prevalence on grouse chicks has increased by 55% in the last 20 years. Climate change is thought to be one of the factors influencing the trend, with milder winters and wetter summers extending the tick feeding season [Smith, 2005b]. On Exmoor, it is now possible to find ticks all year round.
2.4.2.2] Sarcoptic Mange

Sarcoptic mange is a skin disease carried by mites of the genus *Sarcoptes* of which there are many species. *S. scabiei*, the human agent of scabies, does not affect animals, but various animal species can infect humans and cause skin disease. These include the sarcoptic mange of dogs and foxes, amongst which it can cause heavy mortality. [Beesley, 1998; Simpson, 2002]. Cases of sarcoptic mange have been found in red deer in Spain, where it was found to affect stags more frequently than hinds, and adults more often than juvenile deer. However, the overall frequency of infection was low and it was not considered a threat to the red deer population [Oleaga *et al.*, 2008].

2.5] MINERAL AND TRACE ELEMENT DEFICIENCIES

The presence of tiny quantities of copper, selenium, iron, zinc, manganese, cobalt and iodine is essential in animal diets and lack of them, or indeed an excess, can cause health problems.

Little has been written about mineral and trace element deficiencies in wild deer, and it is often assumed that wild populations have evolved a natural resistance to such stresses in their home environment. However, copper deficiency has been diagnosed in farmed red deer and reported in wild North American Elk, which are closely related to red deer [Haig & Hudson, 1993]. Copper supplementation has been found to give a definite visible response in terms of coat colour, general demeanour and condition [van Reenen & Innes, 1985]. In one case in Norway, the provision of a mineral lick was found to be inadequate and daily feeding of a copper-enriched concentrate was necessary [Handeland, 2008].

Copper deficiency is associated with swayback in lambs and in cattle causes unthriftiness, stunted growth and scouring. It is often symptomised by a lightening of the coat or a greying of the hair around the eyes. In farmed red deer, outbreaks of enzootic ataxia are associated with low copper status [Jeffrey, 1994; Miller & West, 1972].

2.6] EXOTIC AND EMERGING DISEASES

Two diseases in particular have the potential to affect red deer on Exmoor, and could potentially have serious implications for farm livestock if outbreaks occurred in the deer herd. Neither can be contracted by humans. However, to date there are no records of either disease being diagnosed in wild deer in the UK.

2.6.1] Bluetongue

Red deer are potential hosts of the bluetongue virus [BTV] and in experimental inoculations red, fallow, roe and muntjac deer all developed a period of infection, with multiplication and shedding of the virus, but none developed serious disease. However, the virus appears to be much more able to become established and to cause disease in the *Odocoileinae* species of deer, which includes roe, than in the *Cervinae* species, such as red deer.

In the recent outbreak of BTV across northern Europe, where there is a high incidence of bluetongue amongst domestic ruminants, the prevalence of the clinical disease in wild deer as been surprisingly low [Deer Commission for Scotland (DCS), 2008]. The Veterinary Laboratory Agency Wild Animal Disease Surveillance (WLDS) Report for September 2007 stated that evidence of BTV infection based upon blood sampling in
Germany, Belgium and the Netherlands was also very low [VLA, WLDS, Sept 2007], but by April 2008, Linden et al., [2008] were reporting that seropositive red deer in affected areas of southern Belgium had increased from 0.9% to over 40% of deer tested between 2006 and 2007. The role of wild deer in the perpetuation or virus multiplication of BTV therefore remains unclear.

The midges that have previously acted as vectors of bluetongue, *Culicoides* spp., are expanding their range northwards due to climate change, and recent work has shown that midges native to England and Scotland are capable of acting as vectors [Meiswinkel et al., 2007]. In particular, the midge *Culicoides scoticus* has very recently been proven to be capable of multiplying and transmitting the virus; this midge is widely present across the Palaeartic region of northern Europe [Carpenter et al., 2008]. The incidence of this disease is expected to increase and is likely to become a permanent feature of UK livestock pathology [Bohm et al., 2007].

### 2.6.2. Foot and Mouth Disease

Red deer are susceptible to foot and mouth disease, along with all cloven footed animals and some others. It is extremely infectious and spreads rapidly if uncontrolled [Thomson et al., 2001; DCS, 2008]. However, it has been suggested that red deer are not good disseminators of FMD virus, and are therefore unlikely to be significant reservoirs of infection [Foreman & Gibbs, 1974, as reported in Mackintosh & Beatson, 1985; and Lawman et al., 1978, as reported in Simpson, 2002].

Past outbreaks in the UK have been controlled by slaughtering infected livestock and there has been concern that if infection spread to wild deer it could prove very difficult to eradicate. This has not happened and there have been no resurgences of the disease that have been attributed to a reservoir of infection in deer. Limited sampling of wild deer in the 2001 UK outbreak revealed no evidence of infection, and the disease was eliminated from areas where deer were abundant by concentrating on domestic livestock alone [VLA, WDSR, Sept 2007]. Nevertheless, the potential involvement of deer in the epidemiology of the disease should be borne in mind in the event of future outbreaks. [Simpson, 2002; Bohm et al., 2007].
3] The current health status of Exmoor domestic livestock; veterinary opinion

During September and October 2008 opinion was gathered from ten veterinary surgeons representing five farm animal veterinary practices providing services to livestock in and around the Exmoor National Park [see Section 8]. Based upon their records, recent experience and sales of preventative or therapeutic medicines, they were asked to review the current health status of the domestic livestock on Exmoor and to indicate whether specific diseases had changed in prevalence in the past five years. The disease monitoring reports, published TB statistics and published surveillance reports of Defra and the Veterinary Laboratories Agency [VLA] were scrutinised. Staff from the VLA were asked to contribute on the basis of their experience. Veterinary surgeons were also invited to contribute their knowledge of the health of the red deer.

The findings of this evidence gathering exercise is as follows:

3.1] Bovine Tuberculosis

Bovine tuberculosis [bTB], caused by the bacteria *Mycobacterium bovis*, is a major problem for Exmoor farmers, with a high level of infection in cattle leading to expensive and restrictive legal requirements for disease control. This disease is of substantial economic importance and many Exmoor farm businesses have been significantly affected as a result. This evidence is consistent with data from Defra. With the exception of one veterinary surgeon, all believed that infected badgers were of major concern. All the veterinary surgeons were aware that bTB had been recovered from red deer on Exmoor and all were also aware that some of their clients were blaming the deer as well as badgers for cattle TB breakdowns. Three of the practices had performed post mortem examinations of deer with bTB [see Section 4].

3.2] Johne's Disease

All the veterinary practices reported an increase in the incidence of clinical Johne's Disease in cattle in and around the moor. One practitioner believed the increase was linked to the popularity of the Limousin breed, others offered no reasons for the increase.

3.3] Leptospirosis

The evidence of the prevalence of leptospirosis in cattle on Exmoor was conflicting: three practices believed that the number of farms with known infection had increased, possibly because of improved detection, and reported increased uptake of vaccination. One practice reported no change in either prevalence or vaccine usage and one practice believed that infection had deceased because of widespread vaccination.

3.4] Salmonellosis

All the veterinary practices, the disease surveillance reports and evidence from the VLA indicated that Salmonellosis continued to be a sporadic, low level problem in the Exmoor region, principally in calves. There had been no change in recent years.

3.5] Bovine Virus Diarrhoea

All the evidence indicated that BVD is endemic in cattle across Exmoor, although the veterinary surgeons reported that awareness of the disease and its implications had improved in the past five years amongst their clients. Only two practices believed that the true prevalence was increasing. The remainder believed that there was a perception of
increase because of improved diagnosis and the availability of a vaccine. This view appears to be borne out by evidence from Defra and the VLA.

3.6] Malignant Catarrhal Fever

This cattle disease has occurred sporadically at low levels for many years. It is not common, but four of the five veterinary practices believed that the incidence was increasing slightly.

3.7] Lyme Disease

One practice, with a particular interest in Lyme Disease, reported an increase in cases of the disease in dogs and believed that cases had been encountered in horses. The other veterinary surgeons were all sceptical about the reliability of diagnostic tests. Whatever the case, all the clinicians agreed that the incidence of disease was very low, but that public awareness of the disease had increased considerably, and that the association between a tick or a tick bite and the possibility of Lyme Disease was commonly made by clients.

3.8] Tick infestation

All the evidence was that tick numbers have increased considerably in the past five years and that tick-borne diseases are more of a problem on Exmoor as a result. These findings are in line with national trends of tick prevalence [see Section 2.4.2.1]. No contributor recognised any tick species other than *Ixodes ricinus* in its various larval, nymphal and adult stages. Several veterinary surgeons believed that the withdrawal of efficient acaricide products, such as the effective organophosphorus base dips and dressings, was responsible, coupled with the lapse of mandatory sheep dipping. Other factors that might influence tick numbers were believed to include the reduction of heather burning as a management tool, climate change and deer numbers.

3.9] Tick Borne Fever [TBF]

In the opinion of all but one of the veterinary surgeons interviewed, TBF had increased significantly in the past five years on Exmoor. The veterinary surgeon who differed from this view believed that the disease had always been common and serious, but was now more regularly diagnosed by farmers, who might previously have ascribed mortality in sheep to acceptable losses. Clinicians reported increased demand for therapeutic drugs for TBF treatment. Reasons given for the increased incidence of TBF were increased tick numbers, an increased tendency to buy-in immunologically naïve sheep and put them in “ticky” areas, the movement of home-bred sheep on and off the moor and climate change. TBF had been recognised in horses in recent years, a new phenomenon for Exmoor veterinary surgeons.

3.10] Redwater Fever [Babesiosis ]

VLA reported no increase in cases of Babesiosis from Exmoor, but pointed out that few clinical cases were traditionally submitted for diagnosis from veterinary practices. Three of the five farm animal practices believed that they were seeing more cases of redwater fever, but all reported that the incidence was very low and that sales of the therapeutic agents were minimal. Where increases in cases had occurred, the affected cattle had usually been moved on to the moor from non-ticky areas and had no resistance to the infection.
3.11] Louping Ill

Four of the five veterinary practices had seen more cases of Louping Ill in the past five years. All reported that particular clients on particular farms had regular problems with the disease and that there were premises where vaccination was necessary to control the problem. Evidence indicated that vaccine sales had increased recently, perhaps suggesting an increased awareness on the part of farmers to the disease.

3.12] Parasitic gastroenteritis

All the Exmoor veterinary practices reported very significantly increased problems with bowel worms in cattle and sheep. This is consistent with national statistics published by Defra and VLA. The disease represents a major factor in limiting livestock productivity and profitability. [see Section 3.15].

3.13] Lungworm

Cattle lungworm on Exmoor has increased in prevalence and the veterinary surgeons also report a change in presentation in some cases, with adult cattle, including dairy herds, succumbing to disease. Traditional ‘husk’ in sub-adult cattle is encountered more regularly, but the increased impact of *D. viviparous* in adult beef and dairy cattle is a recent finding. These reports concur with national statistics provided by Defra and VLA. [see Section 3.15].

3.14] Liver fluke

All the evidence indicated a significant increase in disease and ill-thrift caused by *Facioliasis* on and around Exmoor, in keeping with national trends. The veterinary surgeons reported recent fluke problems on farms that had never been troubled by the parasite before, and where there are no extensive areas of wet ground that would traditionally been designated as “flukey” areas. [see Section 3.15]

3.15] General observations by the veterinary surgeons providing veterinary services to Exmoor farms.

Several of the veterinary surgeons interviewed expressed the view that standards of farming husbandry had declined in recent years on some of their client farms. In some cases, they ascribed this to economic constraints, in others, to the depressing effects of perpetual TB reactors and controls. One factor was cited independently by three of the five veterinary practices consulted – the increased trend towards “organic” or “less intensive” farming, particularly by newcomers to farming, who had less animal husbandry experience than established family farms. The veterinary surgeons expressed concern that the desire to be “organic” and “healthy” had led some of their clients to neglect or consciously to oppose routine preventative medicine, such as worming or vaccination. They believed that in some cases this had contributed to increases in disease, especially to bowel worms, lungworm and fluke disease.
4] The evidence of the current and recent health of the Exmoor red deer

The authors of this report are aware of more than 150 red deer from Exmoor or the immediate vicinity that have either been subject to post mortem examination by veterinary surgeons or from which samples have been submitted for veterinary and laboratory diagnosis between 2000 and September 2008. Details of these investigations have been requested from the landowners, veterinary surgeons, deer managers or agents concerned. Three of the five veterinary practices that offered the evidence summarised in section 3 of this report performed veterinary post mortem examinations on deer from Exmoor farms or landholdings. Two of these practices, with the permission of the clients requesting their professional services, have disclosed in full their findings. The third was approached for their results and quite properly sought the permission of the landowner to make the disclosure. Despite requests to the landowner to make the veterinary evidence available on an anonymous basis, regrettably the data has not been disclosed.

In addition to veterinary post mortem and laboratory results, a full spreadsheet of submissions from Devon and Somerset of deer suspected of having bTB has been provided by Defra. These are identified by map references and include the submissions from the landowner mentioned above who declined to provide evidence to this study.

A recently published study into the prevalence of bTB in wild deer undertaken by Defra, in conjunction with the Central Science Laboratory [CSL] and the Forestry Commission, in 2006 and 2007 included samples taken from deer from the east Exmoor area as well as other areas of public forest throughout the south-west. [Paterson 2008]

The results from a number of red deer examined post mortem by veterinary surgeons at the request of the Devon and Somerset Stag Hounds, The British Deer Society, private landowners and tenant farmers have been made available. In addition, deer managers and stalkers responsible for culling between 600 and 700 red deer from the Exmoor area have been interviewed and their experience sought regarding the condition and health of the deer they have handled. The numbers of red deer culled by stalkers and deer managers who contributed to the study are listed at section 8.

4.1] Bovine Tuberculosis

The national incidence of bTB in wild red deer is considered to be approximately 1% [Delahay et al., 2007]. This is consistent with the recent study by Defra and CSL, which reveals that in the public forests of the south-west of England as a whole bTB was present at less than 1% except in one area where it was present at 3.8% in fallow deer. [Paterson 2008]

The Defra database of submissions of suspected TB cases in all deer from Devon and Somerset reveals that between January 2000 and September 2008, Defra have records of 156 submissions. Of these samples sent to the laboratory as possible TB cases, 97 were returned with a positive result for the culture of M bovis, indicating that 62.2% of deer suspected of having TB by stalkers, deer managers and veterinary surgeons in Devon and Somerset did, in fact, have the disease.

Of the 97 confirmed TB cases in deer in the two counties, nine deer were roe or fallow deer and 88 were red deer, a high relative prevalence, even bearing in mind the relative population proportions of the species. Similar proportions of disease incidence are reported by stalkers and deer managers who have experience of different species of deer on Exmoor and the surrounding areas.
Looking specifically at Exmoor and its borders, the Defra database reports that 84 red deer have been detected with confirmed bTB on and around the moor between January 2000 and September 2008 and five additional cases, not in the Defra database, have been confirmed. These cases are listed at Appendix 1. The distribution of these cases is highly significant. Based upon the map references supplied by Defra, a very large cluster of cases has been discovered in an area to the north east of Dulverton. Specifically, 76 of the TB infected deer have originated from within an area of woodland and farmland represented by a 4 km diameter circle centred on the Exe valley at Baronsdown and Barlynch Farms. Other veterinary records, and records of stalkers and deer managers, suggest that deer in very poor condition have been encountered in the area of the cluster since 1999.

See map of laboratory confirmed cases of bTB in red deer on Exmoor between April 2000 and September 2008 on the following page.

Only 11 cases of red deer with laboratory confirmed bTB have originated from more than 2 km from the centre of this cluster, three of them from just outside the Exmoor National Park boundary. These cases were sporadic and isolated; originating from Streamcombe and Hinam, near Dulverton, Brendon Hill, White Post, Morebath, Twitchen, Exford, East Tapps at Oakfordbridge (2), North Radworthy and Emmetts Grange. Veterinary post mortem examinations have also discovered deer with signs typical of bTB at Parracombe: several cases (5 or 6) were reported by a veterinary surgeon who examined the carcasses of deer taken from that area in the period between 2001 and 2004.

The trend of bTB confirmed cases over time demonstrates that the height of the problem occurred in 2004 and 2005. Between 2000 and 2003 there were only 8 confirmed cases; seven based upon the Baronsdown cluster area and one outside. In 2004, there were 25 confirmed cases, all from the cluster area. In 2005, there were 20 cases, 18 of which came from the cluster area and two from elsewhere. In 2006, only six cases were confirmed, all from the cluster area. In 2007, 12 cases were confirmed from within the cluster area and five cases from elsewhere. At the time of writing in 2008, there have been eight cases based upon the Baronsdown cluster and three from elsewhere on the moor.

It is encouraging that the very high numbers of deer with confirmed bTB in the Baronsdown cluster area during 2004 and 2005 have reduced but the continuing presence of bTB in that area remains much higher than the average elsewhere and is a continuing cause for concern. The high numbers of infected deer, the protracted nature of the disease and the lighter body weights encountered in that area represent a significant welfare issue for the deer, apart from any risk to domestic cattle. Defra [2006] conclude that the risk of transmission of bTB between cattle and deer is low, partly because deer avoid cattle, although this aversion to grazing or lying with cattle is not rigidly observed by Exmoor red deer, which sometimes do graze, feed and lie up in reasonably close proximity to domestic livestock. This may increase the risk of disease transfer.

Apart from the Baronsdown cluster of bTB, the prevalence of the disease in red deer elsewhere on Exmoor and its borders appears to be no greater than the national average, with no more than three cases per annum from a cull of at least 600. The actual incidence of disease amongst living deer in the Exmoor herd is likely to be even lower than this, since many deer are deliberately selected for culling because they appear unwell.
4.2] Lung worm

In a study of wild red deer parasites in the Lasswade area of Scotland over the period 1982-92, Munro [1992] found that the prevalence of *protostrongylid* lungworm disease in red deer rose from 76% to 100% and that the prevalence of *Dictyocaulus viviparous* varied from 8% to 16%.

In the records we have available from Exmoor we have detailed veterinary *post mortem* examination reports for eight deer between 2000 and 2003, all from the Dulverton area. Of these five were confirmed positive for *D. viviparous* and none for *protostrongylid* lungworms. During the 2007/08 winter, 13 red deer from the East Anstey area were fully examined *post mortem* by a veterinary surgeon and samples submitted for laboratory analysis. All 13 deer were infected with *D. viviparous*, some very heavily. Three of the 13 also had *protostrongylid* lungworms, but only at low levels. Lungworm is also widely reported in deer carcases from Exmoor examined by stalkers and huntsmen qualified as trained persons under the current EU Wild Game Regulations, although prevalence has not been quantified.

These results indicate that *D. viviparous* is a significant pathogen of the red deer of Exmoor, in contrast to the red deer of Scotland. In the East Anstey investigation, it was considered to be a major factor in the poor condition of the deer and to be responsible for the observed respiratory distress. Unlike the reported pattern of disease on deer farms [Haigh & Hudson, 1993], the wild red deer of Exmoor do not appear to achieve an age-immunity, since cases of clinical disease in adult hinds have been confirmed by veterinary *post mortem* examination and laboratory identification.

4.3] Parasitic gastroenteritis

Nematode worms of the gut were found consistently in the red deer for which we have detailed laboratory *post mortem* reports. Sporadic cases of apparent disease caused by *Ostertagia* spp. were reported and worm egg counts of up to 600 epg were recorded. These levels are high for wild deer, but only appear to occur in animals debilitated by other disease, such as lungworm or bTB.

4.4] Liver fluke

No patent liver fluke infection was recorded in red deer by any veterinary surgeon performing post mortem examination, although trained persons examining carcases did believe that they had encountered fluke and we believe that these reports are credible. However, the prevalence is almost certainly low.
4.5] Yersiniosis

Of the 13 red deer exhaustively examined and sampled last winter from a farm between Dulverton and East Anstey, *Y. enterocolitica* was cultured from all nine deer culled in December, but not from animals culled in September or March. One hind in December had evidence of reactive and septic arthritis of the carpus (knee), typical of yersiniosis. There may be a seasonal variation in the recovery of *Yersinia* from deer bowels, but to our knowledge the organism has not been looked for in other deer *post mortem* examinations.

4.6] External parasites

Ticks and keds are found frequently on Exmoor deer. Records from the Devon and Somerset Stag Hounds suggest that ticks are found on deer most frequently in spring and autumn, and keds mainly in autumn. However, there are occasional instances of ticks throughout the winter. It is possible that seasonal differences may be related to the sex of deer culled in different seasons, i.e. ticks and keds are found more frequently on stags than hinds, but it is more likely to be related to seasonal parasite activity. All 13 deer examined at East Anstey last winter were either lightly or moderately infested with ticks and keds, including those sampled in December.

4.7] Tick Borne Fever (*Anaplasma phagocytophilum*)

Limited work on *Anaplasma* elsewhere in the Europe has established that red deer are likely to harbour the pathogen at greater prevalence than other deer, wild boar or mouflon. In addition, red deer can harbour the particular genetic variants that cause tick borne fever in sheep and granulocytic anaplasmosis in humans [Zeman & Pecha, 2008]. In a study of deer in England, Birtles & Green [2008, in press] sampled 312 deer from across the country and found a 23% prevalence of all deer positive for *A. phagocytophilum*, with a 50% prevalence in red deer. These investigations employed polymerase chain reaction [PCR] techniques to identify genetic material from the pathogen, revealing the actual presence of the organism circulating in the blood rather than looking for antibodies as an indicator of previous exposure. Significantly all 18 blood samples submitted to the study from Exmoor red deer were positive for the tick-borne fever agent, although there was no evidence of clinical disease in the deer.

4.8] Redwater Fever (*Babesia divergens*)

As part of the study mentioned in section 4.6 above, the same samples were examined by PCR for the presence of *Babesia divergens*, the agent of redwater fever in cattle. One of only two positive deer from the whole of England was from Exmoor; the researchers speculated that the midwinter sampling date may have given a low prevalence because of the inactivity of tick at that time.

4.9] TSEs

A survey to investigate the presence of TSEs in UK red deer is currently being carried out [from January 2007 to the end of the 2008 hunting season]. Samples of brain stem are being tested at the VLA Newcastle laboratory, using the same method as used to detect BSE in cattle. 598 farmed and 598 wild red deer over 18 months of age are being surveyed [Defra, 2008].

Around 30 red deer from the South West have been sampled, having been provided from Forestry Commission larders in February 2007. A small number [around 12] were sourced from Mockham, on the edge of Exmoor. The majority of red deer sampled are
from Scotland, with the aim of reflecting the distribution of red deer in the UK. To date, no positive results have been found from anywhere in the UK. [de Borja & Burke, VLA Newcastle, personal communication.].

4.10] Mineral deficiencies

It is known that livestock on Exmoor farms can be susceptible to deficiencies of copper and selenium. Wild deer on Exmoor have been seen feeding from mineral blocks and licks put out for other livestock. They are also known to visit certain areas where they scrape and lick the ground, and this is believed to be in search of minerals. It is noticeable that Exmoor deer vary considerably in coat colour, but how much this may be due to mineral or trace element deficiency is unknown.

4.11] Accident and injury

A number of deer on Exmoor are regularly found suffering from broken limbs and other injuries as a result of vehicle collisions, being caught up in wire fences, or from rifle or gunshot wounds. The Devon and Somerset Stag Hounds frequently respond to such cases across Exmoor following call-outs by farmers, landowners or anyone who notices deer in distress. These casualty deer also include those noticeably sick. Numbers of casualty deer dealt with are therefore an indication of the prevalence of accident, injury and disease. The low number in 2001/02 is largely contributable to the foot and mouth epidemic. Numbers from 2000 to 2008 are as follows:

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<td>73</td>
<td>59</td>
<td>86</td>
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4.12] Body condition of the deer

Carcase weight is a useful indicator of general body condition. All information sources report that red deer from the Forest and the Chains are lighter and poorer in condition than those from the perimeter of the moor, where there is better grazing and crops. Hinds from the Forest and the north side, Dunkery, Grabbist and the cliffs would be likely to dress out at 43 to 50 kg [95 to 110 lbs]. Hinds from the south side of the moor, Filleigh, Molland and the Barle Valley might be 59 to 66 kg [130 to 145 lbs] and there are some reports of hinds weighing over 80kg [176 lbs] dressed, i.e. eviscerated, head and slots removed, skin on.

It is usual in deer husbandry and management to assess the condition of given populations by reference to the weight of hinds and yearling males, given the very great variation in size and condition of stags. The risk of red deer in deer parks succumbing to adverse weather conditions in the winter is significantly increased if the hogg-dressed carcase larder weights in autumn fall below the threshold of 50 kg for yearling males and 46 kg for hinds [Putnam & Langbein, 2003].

Those deer managers that take deer from the area north east of Dulverton [B, C & E in Table 2 in Section 9.2.1] all report that deer in poor condition are regularly discovered in this part of the National Park. Larder records reveal that red deer from around Dulverton regularly dress out at below 40 kg for both hinds and yearling males.

The reason for the low weights and poor condition of the deer around Dulverton may be linked to the very large epidemiological cluster of bTB. However, this disease alone
cannot explain the low weights, since deer in poor condition are regularly taken from the area with no evidence of bTB, and some very poor animals from the area subjected to veterinary examination during the 2007/08 winter were not tubercular. It may be that other factors, such as lungworm infestation, also contribute to the poor body condition.

A separate, more extensive project to assess deer carcase quality has been commissioned the Exmoor National Park Authority.
5] Transmission of diseases between red deer and livestock and people on Exmoor

5.1 Transmission of diseases between red deer and livestock on Exmoor

There are no reports of peer reviewed research to investigate whether or not the red deer of Exmoor and the domestic livestock of Exmoor transmit diseases between each other. There is evidence, however, that certain diseases that may affect both populations, are increasing in significance to the agricultural community and economy. From the evidence gathered in this study it is clear that the pathogens responsible for the following diseases are present on Exmoor both in deer and in other livestock:

- Bovine tuberculosis
- Lungworm
- Parasitic gastroenteritis
- Liver fluke
- Tick borne fever
- Redwater fever

It is likely that these pathogens are transmitted between deer and other livestock, and vice versa. However, the pathogens responsible for:

- Louping Ill
- Lyme Disease
- Johnne's Disease
- BVD
- Bluetongue

may be present in the Exmoor red deer, but no evidence was found of any objective investigation of these pathogens in deer. If they are present, they are also capable of being transmitted between other livestock and red deer.

5.2 Transmission of disease between red deer and people on Exmoor

A number of zoonoses, or diseases that could potentially be transmitted between red deer and humans on Exmoor have been identified. However, no evidence has been found to confirm that such disease transmission has actually occurred.

Data relating to instances of Lyme borreliosis acquired on Exmoor is obscure, but Exmoor is recognised as one of the foci of the disease and, in 2007, over 68% of infections were acquired in southern counties of England. The numbers of laboratory confirmed cases of Lyme borreliosis in humans in the UK has shown a significant increase between 1996 and 2007, from 140 UK acquired infections in 1997 to 705 in 2007. Most patients acquire infection through recreational or residential risks and some reported occupationally acquired infections. These were mainly forestry and game reserve workers or deer handlers [Defra 2007, HPA 2008].

Bovine TB, *Mycobacterium bovis*, infection in humans is rare, and accounts for less than 1% of all cases of human TB in the UK. It is believed that person-to-person transmission is the usual source of the disease, infection from cattle is now rare, and no reports of infection from deer can be traced [Defra, 2007].
Food-borne and water-borne zoonoses in the UK include *Campylobacters*, *Salmonellae*, *Clostridium perfringens*, *Escherichia coli*, *Cryptosporidium* and *Listeria monocytogenes*. [Defra 2007] These disease pathogens could potentially be transmitted by deer on Exmoor, through water contaminated with faeces or by eating infected venison, but no data could be traced to confirm that this has in fact occurred.

Leptospirosis, a bacterial disease caused by pathogenic serovars of the genus *Leptospira*, is carried by many animals, domestic and wild, most commonly rodents, cattle and pigs. The disease may be contracted through direct contact with an infected animal or from water contaminated with urine from an infected animal. The disease is uncommon and no records linking infection to deer could be traced. [HPA 2008, Defra 2007]
Summary and conclusions

The red deer of Exmoor are generally healthy, but this study highlights several areas of concern:

- Lungworm disease caused by *D. viviparous* occurs in the red deer across Exmoor National Park, but particularly in the south east of this area where it exceeds reported levels of infection from deer elsewhere in the UK. It is possible that red deer and cattle transmit infection between each other.

- Bovine tuberculosis occurs in red deer across Exmoor National Park as a whole at levels no greater than the national average prevalence for deer. However, a large epidemiological cluster of bTB cases has been present in the area just north-east of Dulverton for at least six years. The continuing localised tuberculosis outbreak represents a serious compromise of animal welfare. There is no evidence that the deer transmit infection to cattle, although this possibility cannot be excluded.

- The provision of supplementary feed for deer, whether this is done intentionally or not, encourages the congregation of deer in unnaturally high densities and assists in the transmission of disease. This practice should be discouraged.

- Sporadic cases of parasitic gastro-enteritis are encountered in deer, usually but not invariably associated with other concurrent disease. Liver fluke also occurs at low levels in deer. It is possible that deer and domestic livestock transmit gastro-intestinal helminth parasites between each other.

- The red deer of the Dulverton area compare unfavourably in body condition and carcase weight with deer from elsewhere in the National Park.

- The pathogens responsible for Tick Borne Fever and Redwater Fever have been confirmed in red deer, although there is no evidence that these cause disease in the deer.

- The risk of humans contracting diseases from red deer is very low indeed and does not appear to be any greater on Exmoor than elsewhere in the UK where deer populations are significant.
7] Recommendations and proposals for further studies

- This study raises questions pertinent to the health and welfare of deer and domestic livestock in Exmoor National Park. Sufficient data to make firm conclusions was obtained, but evidence of deer pathology was only available because of the funding of earlier investigations by private individuals and due to the ‘notifiable’ status of TB in deer. All veterinary surgeons consulted and the majority of the deer managers regretted that there is no scheme in place to monitor the health of deer, and were concerned about the possible implications of diseases in deer on domestic livestock.

- Given the high profile that the deer occupy in the heritage, tourism, character, economy and amenity of the Exmoor National Park, it is recommended that the National Park Authority considers establishing a system whereby suspect disease in the deer can be properly investigated and recorded. With this in place, deer managers encountering apparent pathology, through appropriate links with local veterinary practices and the Veterinary Laboratories Agency, could have access to a proper means of investigation of deer health problems. Ideally, the National Park Authority would initiate, set up and financially support a database for the objective monitoring of deer health and welfare. This would have implications for deer management and livestock health in general, and could inform future livestock health planning in the area.

- In the short term, academic research teams are anxious to pursue the investigation of tick-borne diseases of livestock, and their prevalence in deer, as well as the investigation of helminth parasites of deer. This work should be encouraged and promoted.

- There is concern over the implications of providing supplementary feed for deer, whether intentionally or unintentionally, and the dangers of this have been highlighted. Whether or not the deer are deliberately provided with supplementary feed within the National park should be investigated. It would also be instructive to assess the extent to which deer have incidental access to feed as a result of pheasant rearing and keepering, and to examine the role of game shooting on the health and welfare of deer on Exmoor.

- The National Park Authority should provide information, encouragement and support to landowners and deer managers who seek to practice informed and co-operative deer management. The value to the deer of having a population that is balanced in terms of sex and age ratios, habitat impact and population density should be promoted. Whilst recognising and respecting the freedom of individual landowners to decide upon the deer management on their properties, the National Park Authority should make clear the need to control the population of deer across the Park as a whole, both for the benefit of the health of the deer and to achieve an optimal balance between conservation, recreation and farming.

- The continuing cluster of bTB in deer in the Dulverton area warrants further attention. Given that the character of the habitat, farming practices and deer numbers do not appear to be unique to this limited area, the National Park Authority should consider commissioning study to attempt to determine the reasons for this outbreak and its persistence.
8] Sources and acknowledgements

8.1] CONTRIBUTORS

The preparation of this report has only been possible with the co-operation of and information from a number of individuals. In particular, we gratefully acknowledge the invaluable contributions of:

Simon White, MRCVS, & colleagues, White Lodge Veterinary Clinic, Minehead.
Charlie Sullivan, Horsepond Veterinary Practice, South Molton.
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Martin Fieldhouse, Dulverton Veterinary Centre
Richard Sibley, West Ridge Veterinary Practice, Witheridge
David Denny, Henwick Road, Worcester.
John Fletcher, MRCVS, Fife
Richard Birtles, Dept. of Conservation Medicine, University of Liverpool, Faculty of Veterinary Science.
Tim Crawshaw, Defra
Andy Paterson, Defra
Alex Barlow, VLA
David de Borja, VLA
Patrick Burke, VLA
The British Deer Society
The Deer Initiative
The Exmoor and District Deer Management Society
The Devon and Somerset Staghounds
Christopher Beatson-Hird
Charles Harding
Jeremy Boyd
Tony Whitaker
Karl Johan Larsen
Stanley Stanbury
Darryn Northcott
Glen Dallyn

We would also like to express our thanks to the many other landowners, farmers, deer managers and interested individuals who have provided information or advice, and who have asked to remain anonymous.
8.2] DEER MANAGEMENT CULL FIGURES AND VETERINARY RECORDS

8.2.1] Numbers of red deer culled

From reports and larder records

Table 1]

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<tr>
<th>Deer manager / stalker</th>
<th>Area of the moor</th>
<th>Average annual number of red deer culled 2000-08</th>
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<td>C</td>
<td>Central and south</td>
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Table 2]

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<th>Game dealer</th>
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8.2.2] Veterinary and laboratory inspections

Records of deer between 2000 and 2008 from Exmoor made available to the study:

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<th>Source</th>
<th>Full veterinary post mortem</th>
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9] References


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All websites accessed October 2008.
### Appendix 1

Cases of laboratory confirmed bTB on Exmoor April 2000 to September 2008

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