Hunting with hounds and the spread of disease

Professor Stephen Harris BSc PhD DSc
Dr Jo Dorning BSc PhD

A report commissioned by the League Against Cruel Sports

December 2017

All photographs courtesy of the League Against Cruel Sports

Hunting with hounds and the spread of disease

Professor Stephen Harris
BSc PhD DSc

Dr Jo Dorning
BSc PhD

A report commissioned by the League Against Cruel Sports

December 2017

Executive summary

1. Animal diseases have taken a heavy toll on the agricultural economy, and some also pose a health risk to humans. The term biosecurity came to the forefront of animal health during the 2001 foot-and-mouth disease epidemic, and is now both a cornerstone of disease control and a legal requirement.

2. Basic biosecurity advice for all types of livestock farming highlight: the risks of moving personnel, equipment and vehicles between farms, and the importance of minimising such movements; the need to thoroughly disinfect people, equipment and vehicles before they arrive at a farm and before they move onto another farm; the importance of keeping visiting vehicles away from livestock and the need to provide hard standing so that all mud and faeces adhering to the vehicle (and equipment) can be cleaned off, preferably with a power hose, before the vehicle enters the farm and before it leaves; and the importance of not transferring soil, slurry and faecal material to other farms on the wheels of vehicles or on the feet of animals. Hunts contravene all of these basic biosecurity measures during a day's hunting, with large numbers of horses, dogs, people and vehicles moving between farms and across farmland without implementing any of the recommended biosecurity measures.

3. Fouling by dogs is a particular health issue for many farmers, but the focus on dog fouling of agricultural land has been on companion animals. A survey in Scotland found that almost 40% of farmers had livestock that had contracted disease as a result of dog fouling on their grazing land. Dog owners are requested, but not required, to clear up their dog's faeces in rural areas. They are also requested to ensure that: their dogs are wormed regularly; to keep their dogs out of fields with vegetable and soft fruit crops; not to move from one farm to another; to keep their dogs on a lead near livestock, especially young livestock; to keep to footpaths to minimise the risks of disease transmission; and not to allow their dogs to drink from livestock water troughs or to foul water supplies that may be used to supply drinking water. Unlike pet dogs, packs of hounds are out of sight of, and often a long way from, the huntsman, when hunting, so it is impossible to collect their faeces, to keep them away from livestock and vegetable crops, or to prevent them drinking from water troughs. Fouling of water supplies is a particular concern for minkhounds, which routinely hunt in streams, rivers and lakes.

4. The risks of disease transmission by hunts are heightened by sporting visits, whereby hunts take horses, hounds, vehicles and followers to hunt in different parts of the country, often long distances from their home base. Many of these sporting visits are made when the local pack of hounds is ill and unable to operate. Kennel cough is often the cause, but more significant diseases can also be involved. Hunts were making sporting visits to the Kimblewick Hunt's country when their hounds were quarantined due to the most extensive outbreak of bovine tuberculosis ever recorded in dogs in Britain.

5. Hounds are displayed at several hundred events a year where they have direct and indirect contact with other packs of hounds, livestock, and members of the public. While strict biosecurity rules apply to livestock displayed at shows, and farmers are advised to quarantine stock returning from a show, no such regulations apply to packs of hounds. While there are benefits of human/animal contacts at such shows, there are significant risks of disease transmission, especially to children because of their immature immune systems and poor standards of hygiene. There are also significant risks of disease transmission to other animals, as shown by the spread of kennel cough between packs of hounds in Britain and leishmaniosis between packs of foxhounds in North America.

6. Hounds require a high-energy diet, especially during the hunting season. Prior to the Second World War, most hunts fed their hounds on a porridge pudding with cooked meat added, but war-time restrictions on using oats to feed animals and rising fuel and labour costs meant that most hunts now rely on raw flesh, even though the disease risks of feeding raw flesh to hounds have been recognised by hunts for two centuries. A number of veterinary organisations have issued advice urging people not to feed raw meat to dogs because of the health risks to the dogs and the risks of disease transmission to humans. Raw meat can carry a number of life-threatening pathogens for humans, and feeding raw meat diets to working and other dogs in contact with livestock perpetuates a number of costly diseases in livestock populations.

7. For the last fifty years feeding raw meat and offal from fallen stock has been portrayed as a service to farmers. The Meat (Sterilization) Regulations 1969 and subsequent legislation were designed to restrict the use of meat not fit for human consumption. However, hunt kennels were viewed as a service rather than a trade and so were unlicensed and could continue to obtain fallen stock or casualty animals from farmers. At the time this was described as a loophole in the regulations. Collecting fallen stock is still portrayed by hunts as a service to farmers. While it is impossible to quantify the disease risks, and associated financial costs to the agricultural sector, of feeding fallen stock to hounds, collecting fallen stock by hunts is likely to be a financial burden to farmers rather than a service.

8. The number of hunts that collect fallen stock is unclear, but most hunts are registered with Defra as approved animal by-product plants. The number of fallen stock collected by hunts and fed to hounds as raw flesh is likely to be several hundred-thousand: some hunts obtain most of the fallen stock in their area. Fallen stock is either collected by hunts or delivered by local farmers: the charges for delivering fallen stock to hunt kennels are lower than asking for the hunt to make the collection. EU Regulations specify how fallen stock must be collected and transported to minimise the risk of disease transfer: it is unclear how well these rules are observed by hunt staff, or the guidance given to hunts on how to minimise the risks of disease transmission. Nor is it clear whether farmers who deliver their own fallen stock to kennels observe the biosecurity rules. A number of studies have identified fallen stock collectors as the farm visitors least likely to follow basic biosecurity rules, even though they pose a particularly high risk of disease transmission. Hunt staff and vehicles also pose a particular disease risk because they often enter livestock areas when they are required to slaughter animals.

9. Causes of death for fallen stock are not routinely recorded, but one exploratory study identified hundreds of different causes of death, including a wide range of diseases that can be transmitted to both animals and humans. It is impossible to know the cause of death of fallen stock without a routine post mortem of each animal. Twenty years ago the EU's Scientific Steering Committee said that, because it was impossible to determine the cause of death for each animal, fallen stock should not be fed to hounds. Whether or not individual carcases are from animals that have died of disease, the high proportion of fallen stock that are infected with a range of pathogens means that it is inevitable that hounds are regularly fed with livestock that has died from a disease that could infect animals and/or humans. Hunts routinely contravene the regulations that forbid using fallen stock that has died of disease as animal feed.

10. While a large number of hounds (probably over 4000) are culled from packs each year, there is remarkably little information on the health of hunting hounds in Britain. Most are culled when they are no longer able to hunt with the pack, usually when between half and two-thirds of their normal life expectancy, and this is likely to be due to an underlying health issue. Hounds that are culled are

rarely examined *post mortem*, thereby allowing infectious diseases to go unnoticed and either spread within the pack and/or to livestock. However, the limited data available suggest that several hundred of the hounds culled each year are likely to have been infected with a variety of diseases, many of which pose a risk to livestock and/or humans.

11. Some of the best data on the role of hounds in spreading livestock diseases are for tapeworms. The change to feeding raw horse flesh and offal to hounds after the Second World War led to a dramatic increase in both the prevalence and distribution of equine hydatidosis. Hounds, and other working dogs, are also important in spreading ovine hydatidosis and other cestodes to sheep. A number of studies have shown the link between feeding raw meat and offal from fallen stock, and poor veterinary care, and the level of infestation in packs of hounds. Hounds are particularly important in spreading these parasites because of the number of hounds in each pack. These spread infective ova from tapeworms onto grazing land over wide areas of the countryside. There is also a high risk of contamination in fields and on the verges of roads where hounds are exercised regularly. In addition, the hounds are often housed, exercised and transported in close proximity to livestock, especially horses, thereby facilitating transmission of a variety of diseases.

12. Despite the lack of quantified data, a wide range of diseases, including zoonoses and notifiable diseases, have been recorded in packs of hounds in the UK and elsewhere in the world. These data show that there are a number of common risk factors associated with hunting hounds becoming infected with, and spreading, livestock and other diseases. These include: feeding raw meat and offal; poor standards of kennel hygiene; lack of adequate veterinary care; lack of routine monitoring of disease; close contact with livestock; and interacting with other packs of hounds. Allowing hounds to break up the carcases of dead foxes poses a particular risk that hounds will become infected with a range of parasites and diseases.

13. While the risks of disease transmission by hounds could be reduced by effective management and veterinary programmes, there is a lack of transparency on the veterinary care of British hounds, and hounds tend to be culled from the pack rather than receive veterinary treatment. This makes it difficult to assess whether the health treatment programmes implemented by UK packs of hounds are adequate. However, the information that has been published suggests that vaccination and worming programmes are inadequate to limit the spread of disease, and it would appear that the *Code of practice* issued for hunt kennels by the Council of Hunting Associations is widely ignored. Veterinary treatment of hounds appears to be a major drain on the finances of at least some hunts, and the health care of hounds is focussed on infections such as kennel cough, which curtail hunting, rather than diseases that pose a significant risk to livestock and/or humans.

14. While hunting with hounds maintains and/or spreads a number of livestock parasites and pathogens that have a major economic impact on British farmers, and pose a significant health risk to humans, it is impossible to quantify the exact costs that are involved. For some diseases, such as equine hydatidosis, feeding hounds on raw meat and offal after the Second World War was the major factor leading to a dramatic increase in both the prevalence and distribution of the disease. For diseases such as ovine hydatidosis and sheep tapeworms that cause a major economic loss to farmers, hunts make a significant contribution to maintaining and spreading the infections. For other diseases, it is harder to identify the exact contribution made by hunts to the overall spread of infection. However, in view of the economic losses farmers incur due to livestock diseases, hunting with hounds is likely to impose a substantial financial burden on livestock farmers.

15. In addition to the existing health risks, The Pet Travel Scheme has increased the risk that dogs will introduce novel diseases to Britain. Hunts pose a particular risk of introducing some of these diseases following sporting visits to European countries where zoonoses of concern are endemic. Should leishmaniosis be introduced to Britain and/or Ireland, it is likely the foxhounds will maintain and spread the disease, as occurred in North America. The high prevalence levels of leishmaniosis in foxes in parts of Europe highlights the risks of allowing hounds to break up the bodies of foxes. Should alveolar echinococcus (a significant public health concern in Europe) be introduced to Britain, foxes are the main host of the parasite (*Echinococcus multilocularis*) and hunts are likely to exacerbate the spread of the disease by increasing dispersal movements of juvenile foxes, and by spreading eggs while hunting. There are a number of other zoonoses that could be introduced to Britain that may be spread by hunts feeding infected fox carcases to their hounds.

16. Thus all aspects of hunting with hounds pose a significant risk of disease transmission to both livestock and humans.

Contents

Introduction 05

Biosecurity 05

Farm-level biosecurity measures 06

General biosecurity 06
Cattle farms 07
Sheep farms 08
Pig units 08
The role of faeces in spreading livestock diseases 08

Fouling by dogs 09

Dogs in the countryside 09
Legislation and advice on dog fouling 10

Biosecurity and hunting with hounds 11

Background 11
A day's hunting 12
Sporting visits 12
Biosecurity advice from the hunting organisations 13

Showing hounds at public events 14

Events attended by working hounds 14
Biosecurity at animal gatherings 15
Spread of diseases at animal shows 15

Feeding hounds 16

Energy requirements of hounds 16
Changes in feeding practices 17
Feeding hounds on hunting days 17

Health risks of feeding raw meat to dogs 18

The risks to companion animals 18
The risks to working dogs 20

Collection of fallen stock by hunts 21

Changes in legislation 21
Disposal of fallen stock 22
Number of fallen stock collected by hunts in the past 24
Number of fallen stock currently collected by hunts 25
Transport of fallen stock 26

The risks of using fallen stock as animal feed 27

Causes of death of fallen stock 27
Should hounds be fed on fallen stock? 28

The main diseases spread by dogs to livestock 29

Companion animals 29
Hounds and hunting dogs 30
The role of hounds in spreading equine hydatidosis 35
The role of hounds in spreading ovine hydatidosis and other tapeworms 36
Diseases in hounds elsewhere in the world 36
Disease risks of feeding dead foxes to hounds 40

Health treatment of hounds 40

Basic principles 40
Veterinary care of American foxhounds 41
Vaccination programmes for British hounds 42
Anthelmintic treatment of British hounds 42
Costs of veterinary care for hounds 43

The economic impact of livestock diseases 44

Cestodes in sheep 44
Johne's disease (paratuberculosis) 44
Toxoplasmosis 45
A few other examples 45

Future risks 45

The risks of pet travel 45
Zoonotic risks associated with packs of hounds 46

Conclusions 48

References 49

Introduction

The League Against Cruel Sports (LACS) asked us to review the disease risks posed by packs of hounds, in particular the risks to livestock and humans. There were a number of issues to consider:-

- Biosecurity measures recommended for, and/or adopted by, British livestock farmers
- The biosecurity measures adopted by hunts when operating packs of hounds on farmland and elsewhere in the countryside, and how these conform to the biosecurity measures recommended for livestock farmers
- Fouling of farmland by dog faeces and the risks these pose to both livestock and humans
- The health risks associated with the collection of fallen stock for feeding hounds
- The potential health risks of using raw flesh and offal to feed hounds
- The potential health risks associated with allowing hounds to break up fox and hare carcases
- Hygiene standards in hound kennels and the veterinary treatment of hounds
- The movements of hounds around the country and their interactions with other packs of hounds, livestock and humans
- Parasites and diseases recorded in hounds and other dogs that might be transmitted to livestock and humans
- Cases where packs of hounds have been associated with disease in livestock and humans
- The potential economic impact of hunts on livestock farming in Britain
- The potential for novel canine diseases and zoonoses to be introduced to Britain

We identified relevant published papers, reports, books, press articles, leaflets, guidance documents and government legislation using keyword searches in the Web of Science, Google Scholar and Google, searching for different combinations of the keywords in Box 1.

Box 1. Keywords used in the literature search

Animal disposal, bacteria, beef, biosecurity, bovine, Britain, carcass, cattle, deadstock, disease, disposal, dog, dog faeces, England, fallen (live) stock, farm, feeding raw meat, fluke, fox hunting, foxhound, foxhunt, horses, hound, hunting dog, husbandry, infection, Ireland, kennels, *Leishmania*, leptospirosis, livestock, meat, miles distance, *Neospora*, parasite, pigs, pork, prion, red fox, risk, *Salmonella*, Scotland, spread, swine, tapeworm, transit time, transmission, tuberculosis, vector, virus, Wales

We focused on literature relevant to livestock (excluding poultry) in Great Britain, but have included literature on diseases in other countries where there is a risk that they might enter Britain in the future, and/or where information from abroad was relevant to understanding the current situation in Britain. We have also referred to more general literature on companion, working and feral dogs where it was relevant. Our search returned 415 peer-reviewed scientific papers, including 375 papers about biosecurity and disease, 35 about dog diet, metabolism and feeding raw meat, and five about hunting with dogs in general, 60 reports, 82 press articles and six webpages. These sources were then used to identify other relevant publications, which were accessed, read, and their relevance assessed.

Since there was considerable overlap in information between sources (particularly between reports and advice leaflets), we have only cited selected publications. All the websites referred to were accessed between August and December 2017.

Biosecurity

Animal disease has taken a heavy toll on the agricultural economy, and the term biosecurity came to the forefront of animal health during the 2001 foot-and-mouth disease (FMD) epidemic (Brennan & Christley, 2012). Biosecurity is now both a cornerstone of disease control and a legal requirement (Sayers *et al.*, 2013; Toma *et al.*, 2013). UK government policy on animal health has placed farmers in the forefront of livestock disease prevention and control, since they are best placed to manage risks and have most to gain from disease control (Defra, 2004; Scottish Executive, 2006; Toma *et al.*, 2013). However, collective action regarding biosecurity among UK cattle and sheep farmers is rare (Heffernan *et al.*, 2008). In a survey of over 800 farmers by Farmers Weekly, 82% admitted that their biosecurity was not up to standard and was almost non-existent for 34% (Anon., 2007). So biosecurity uptake and implementation on UK livestock farms remains poor, despite strong evidence to show the considerable net benefits from investment in biosecurity at the farm level (Anon., 2007; Gunn *et al.*, 2008; Toma *et al.*, 2013).

The significant resistance to the implementation of farm-level biosecurity by farmers is in part because governance of the food chain is complex: international trade rules and European directives provide the regulatory backdrop; national governments create policies and the institutions to implement them; while at a local level, public agencies, local authorities and private companies are responsible for ensuring that food is safe for human consumption on a day-to-day basis (Enticott *et al.*, 2011).

A key factor influencing the attitudes and behaviour of farmers is access to information on biosecurity and

animal health (Toma *et al.*, 2013). While biosecurity recommendations for cattle farmers from Defra emphasize minimization of disease transmission between premises via contaminated clothing, vehicles and equipment, this may be of limited use to cattle producers due to, among other issues, a lack of evidence of efficacy (Brennan & Christley, 2012). The increased incidence of bovine tuberculosis (bTB) on farms restocked after the 2001 FMD epidemic, and an increase in endemic diseases such as bovine viral diarrhoea, infectious bovine rhinotracheitis and Johne's disease (paratuberculosis) may all reflect poor biosecurity practices on these farms (Holliman, 2003). The same probably applies to the introduction and wide distribution of bovine viral diarrhoea and infectious bovine rhinotracheitis in Ireland, and the dramatic increase in the levels of Johne's disease, following an increase in importation of livestock in the early 1990s (Sayers, 2009).

While biosecurity is essential for controlling livestock diseases, and is a legal requirement in the UK, biosecurity measures on farms remain poor, in part because of a lack of evidence of efficacy. Recent increases in, and spread of, a number of livestock diseases are probably due to poor biosecurity standards

Farm-level biosecurity measures

General biosecurity

Farm-level biosecurity is key to preventing the spread of livestock diseases and protecting agricultural workers and visitors (**https://www.gov.uk/guidance/controlling-disease-in-farm-animals**). The Animal Plant and Health Agency (APHA) and Defra's general disease prevention advice for livestock farmers is that they should not bring infection onto their farm, or spread it around their farm, on their clothes, footwear or hands. Specific advice includes limiting and controlling farm visitors; having pressure washers, brushes, hoses, water and disinfectant available, and making sure visitors use them; keeping farm access routes, parking areas, yards, feeding and storage areas clean and tidy; banning vehicles, equipment and clothing contaminated with animal excreta; cleaning and then disinfecting any farm machinery/equipment that is being shared with, or moved between, neighbouring farms; cleaning contamination from clothes, and cleaning and disinfecting boots, before leaving animal areas; disposing of fallen stock properly; keeping vehicles clean inside and out; and cleaning and disinfecting vehicles and trailers (preferably with a power hose), paying particular attention to areas where dirt may be hidden such as wheel arches (**https://www.gov.uk/guidance/diseasepreventionforlivestockfarmers**; **https://www.gov.uk/guidance/controllingdiseaseinfarmanimals**). It is particularly important to control and reduce movements of animals, people and vehicles to and from areas where livestock is kept (Brennan & Christley, 2012).

Similar advice applies to the rest of Britain and Ireland. In their biosecurity advice to smallholders, the Scottish Government highlights that diseases and parasites can spread between farm animals and pets. Their advice is to:-

- ensure that your pets are regularly wormed; dogs should be given anti-tapeworm treatment on a regular basis
- make sure that delivery and pick up points should be as far away from stock areas as possible
- locate the knackery collection point as near to the farm entrance to avoid the collection vehicle driving through your premises. Ideally, a sign should be used to identify the area as a pick up point. The area should be on hard standing so that it can be easily cleansed and disinfected

(**https://www.sruc.ac.uk/download/downloads/id/.../biosecurity_for_smallholders.pdf**). The advice for Northern Ireland and the Republic of Ireland is summarised in Boxes 2 and 3.

Dogs should be kept out of fields grazed by livestock

Box 2. Some of the biosecurity advice for Northern Ireland (Anon., 2004)

Each farm should have a collection area for fallen animals, capable of being cleansed and disinfected. Site as far away from animals and as near the farm entrance as possible, so that contact with the fallen animal collection vehicle is kept to a minimum. Keep fallen animals covered, or if possible, in a sealed polythene bag, or in a leak-proof covered bin or container. Cleanse and disinfect the site, equipment or containers used, after removal of the carcase

Thoroughly clean and disinfect all vehicles if they have had contact with livestock from other premises

All vehicles, machinery and equipment must be cleaned and disinfected before going onto and before leaving the farm

Avoid sharing trailers and other machinery. If hauliers or contractors must be used, inspect for cleanliness and disinfection

Provide a washing area, brush, water and disinfectant or equivalent facilities for all visitors/workers on arrival and departure

Visitors should advise the farmer if they have previously been on other livestock premises that day

Box 3. Some key points in Animal Health Ireland's advice on biosecurity in the Republic of Ireland (**http://www.animalhealthni.com/Biosecurity/20170609%20AHWNI%20Bioexclusion%20leaflet.pdf**)

Keep troughs at a height that they can only be accessed by your cattle

Water troughs should be regularly checked to ensure they are clean

Disinfect boots and change gloves when moving between animal groups within the farm

Ensure disinfection of visitor's clothing, boots, hands and equipment (bio-exclusion) on arrival

Provide boots and clothing for veterinary practitioners and other essential visitors to animals

Dogs should be kept out of fields of vegetable crops

Different measures apply to different types of livestock, and some of the advice relevant to this review is listed below.

Cattle farms

The advice to cattle farmers (**www.xlvets-farm.co.uk/make-your-farm-your-fortress**) is that farm contractors, people who move between farms, other farmers, livestock hauliers and deadstock collectors are high-risk visitors. Methods of reducing risk include:-

- providing high-risk personnel with protective clothing and boots to use and leave on farm
- ensuring that all contractor's vehicles and trailers accessing livestock areas should be clean and free of visible manure on the outside of the vehicle, wheels, mudguards and wheel arches
- asking all high-risk visitors to arrive wearing clean protective clothing and boots, and to ensure that all their equipment is disinfected
- ensuring that no equipment and machinery is shared with other farms
- providing wash station and disinfectant sprayers for incoming vehicles and equipment
- ensuring that a suitable length of time has passed before stock are allowed to graze fields recently spread with manure or slurry
- assessing the disease risks posed by fields accessed by dogs from public footpaths

Not providing boots for visitors was identified as a significant risk factor for diseases such as bovine coronavirus and bovine respiratory syncitial virus (Mee *et al.*, 2012).

Since bTB is a particular problem for cattle farmers (**https://www.gov.uk/government/publications/protecting-cattle-against-tb-infection-in-high-incidence-areas**), biosecurity advice to prevent the spread of bTB includes:-

- ensuring that any farm machinery and equipment shared with another farm is cleansed and disinfected
- ensuring that any contractors used are scrupulous about their own biosecurity

Sheep farms

Most UK sheep farmers take no animal health precautions either when introducing purchased animals to their flocks or at farm boundaries. As a result, infectious diseases are very common and cost the industry millions of pounds through less efficient production (Hosie & Clark, 2007). Key advice from the National Animal Disease Information Service (**www.nadis.org.uk/bulletins/biosecurity-on-sheep-farms.aspx**) is that:-

- vehicles used to collect fallen stock are a major potential biosecurity hazard, and so delivery and pick-up points should be at the margins of the farm
- the delivery and pick-up point should have a concrete surface to allow effective cleaning and disinfection
- vehicles must be cleaned and disinfected with an appropriate disinfectant before they are used for moving stock
- people who have had contact with other farms should be prevented from entry

It is important that the rules for staff must also apply to visitors (Hosie & Clark, 2007).

Pig units

To prevent the spread of disease (**http://pork.ahdb.org.uk/pig-production/biosecurity**; **https://pork.ahdb.org.uk/media/2726/visitor_factsheet.pdf**), pig farmers should:-

- keep vehicles outside the perimeter of the unit
- only allow the unit's own vehicles and machinery to enter
- clean and disinfect vehicles and machinery that has been off site
- control the areas accessible by vehicles, keeping them as far away as possible from buildings and livestock
- dispose of fallen stock promptly and correctly: provide safe, sealed storage for dead pigs, in line with legal requirements
- provide a fallen stock collection point away from the pig housing with clear demarcation between the farm access and the collection service access
- keep the fallen stock collection point and associated equipment clean and disinfect after every use
- schedule transport of fallen stock to allow cleaning and down-time following the visit before going to another farm
- ensure that vehicles attending the farm are adequately and appropriately cleaned and disinfected first

Key to ensuring effective biosecurity at pig units is logging all movements of people and animals onto, and off, the farm (Amass & Clark, 1999).

One of the common themes to the biosecurity advice from farming and veterinary organisations is the need for a much better understanding of how transmission between farms is mediated by fomites i.e. objects or materials such as faeces which are moved between farms and are likely to carry infection. Farm visitors carry pathogens on their clothes, equipment, or vehicles; this can substantially enhance the spread of disease, both locally and at larger spatial scales (Rossi *et al.*, 2017a,b).

The role of faeces in spreading livestock diseases

In England and Wales, 67.3 million tonnes of animal manure are collected annually from farm buildings and yards (53 million tonnes from cattle, 8.9 million tonnes from pigs, 3.5 million tonnes from poultry, 1.9 million tonnes from sheep). Approximately 45% is applied as solid-based manures, and the remainder as liquid slurries, mostly cattle and pig manures. Animal manures are applied annually to around 16% of tilled land in England and Wales (0.6 million hectares) and 48% of grassland (2.3 million hectares). While manures are applied throughout the year, about 50% of pig and poultry manures are applied in the autumn (August-October), mainly to cereal stubbles in predominantly arable areas where most pig and poultry units are located. About 40% of cattle slurry is applied in spring (February-April) and 70% of straw-based cattle farmyard manure is split fairly evenly between autumn and spring dressings. So much of this is spread on fields when hunts are most active. A further 45 million tonnes of excreta are deposited directly in the field by grazing cattle, sheep and pigs (Chambers *et al.*, 2000).

A key biosecurity issue is to avoid transferring animal faeces, slurry and manures between farms. Over 30% of the livestock wastes examined in one study contained at least one microbial pathogen (*Campylobacter, Cryptosporidium, Escherichia coli* O157, *Giardia*, pathogenic *Listeria* and *Salmonella*; Hutchinson *et al.*, 2004), and these zoonotic agents can survive for several months in liquid livestock wastes (Hutchison *et al.*, 2005).

Fomites have been implicated in the indirect transmission of various cattle pathogens such as bovine viral diarrhoea, FMD, *Cryptosporidium* and ovine herpesvirus 2, the cause of malignant catarrhal fever (Mee *et al.*, 2012). A review of the indirect means of transmission of bTB concluded that improperly managed manures could constitute a potential infection risk for livestock, particularly if pathogenic organisms such as *Salmonella*, *Clostridia*, *Escherichia coli* and mycobacteria (the bacteria that cause both Johne's disease and bTB), are present in animal excretions. Solid manure does not present a risk if it has been well composted, whereas slurry is extremely unlikely to reach high temperatures during storage and so pathogenic bacteria are more

likely to survive for longer. There is a higher risk of bTB for farmers if they use slurry contractors, highlighting the risk of spreading the disease between farms, and the need for vehicles and equipment to be thoroughly cleansed and disinfected before moving between farms (McCallan *et al.*, 2014).

How long fomites remain infectious depends on the nature of the agent and environmental factors such as temperature, exposure to ultraviolet light and the efficacy of disinfection procedures. Porcine parvovirus and porcine circovirus type 2, for example, survive for several months under common UK environmental conditions. *Brachyspira hyodysenteriae*, the cause of swine dysentery, can survive in moist faeces for up to 40 days (Pritchard *et al.*, 2005). In winter, *Mycobacterium bovis* (the organism that causes bTB) may remain infective in faeces for about six months, and environmental contamination is an important indirect route of bTB transmission to cattle (McCallan *et al.*, 2014).

Animals in advanced stages of Johne's disease can shed vast quantities of bacteria in their faeces (**http://www.feedforgrowth.com/assets/ffg_johnes_disease_09.02.16.pdf**) and, to control Johne's disease and salmonellosis, all grazing land should be left for at least three weeks after spreading slurry, and all visitors must have clean boots and disinfect before entering and leaving a farm (**http://www.nadis.org.uk/bulletins/biosecurityindairyandbeefcattle.aspx**).

Of 55 suspected cases of botulism in cattle in England and Wales in 2003-2005, 39 were due to poultry litter spread on adjacent fields or farms; animals spread the toxic material to fields where cattle had access (**https://acmsf.food.gov.uk/sites/default/files/mnt/.../botulismcattlereport1206.pdf**). Botulism is rarer in sheep but is also associated with spreading poultry litter on grazing land and subsequent spread of infection by other animals (Advisory Committee on the Microbiological Safety of Food, 2009).

Common biosecurity issues for all types of livestock farming include: the risks of moving personnel, equipment and vehicles between farms; the need to minimise such movements; the importance of restricting the number of farm visitors; and the need to thoroughly disinfect people, equipment and vehicles before they arrive and before they move onto another farm. Fomites, especially faeces, pose a high risk of transfer between farms. Vehicles visiting farms should be kept away from livestock and there should be some form of hard standing so that all mud and faeces adhering to the vehicle (and equipment) can be cleaned off, preferably with a power hose. Particular attention should be given to tyres, wheel arches, and other areas where mud and/or faeces might adhere

Fouling by dogs

Dogs in the countryside

Fouling by dogs is a particular biosecurity issue for farmers. In 2000-2001 there were an estimated 6.5 to 7.4 million dogs in the UK, producing around 1,000 tonnes of faeces each day (Campbell, 2007; Anon., 2015a). It is a common perception that dog fouling is a more significant issue in urban than rural areas, even though Scottish National Heritage estimated that during 2013/2014 almost 48% of the visits to the outdoors in the UK included a dog, equating to an estimated 188.9 million visits, and an NFU Scotland survey found that almost 40% of farmers had livestock that had contracted disease as a result of dog fouling on grazing land (Anon., 2015a).

From 2004 in England, and 2005 in Wales, the Countryside and Rights of Way Act 2000 gave people the right to walk across most downland, heathland, moorland, registered common land, and some land around the England Coast Path, rather than just use specific paths (**http://jncc.defra.gov.uk/page-1378**). One fifth of Wales is access land and it also includes areas of dedicated land where owners, such as Natural Resources Wales, allow free access (**https://naturalresources.wales/days-out/recreation-and-access-policy-advice-and-guidance/managing-access/open-access-land/?lang=en**). However, to protect farm animals and ground-nesting birds, this general right of access is conditional on dogs being kept on a fixed length lead, of no more than 2 metres long, between 1 March to 31 July each year, and at any time in the vicinity of livestock, although there is no legal definition of the point when a dog is in the vicinity of livestock; there may be other local or seasonal restrictions (**http://documents.hants.gov.uk/countryside/dogsonyourland.pdf**). Dogs must be under effective control at all times in the coastal margins, and under some circumstances, landowners can exclude people with dogs completely from a field used for lambing and from land managed as a grouse moor (**https://www.gov.uk/guidance/open-access-land-management-rights-and-responsibilities**). The restrictions do not apply to public rights of way or assistance dogs (**https://www.gov.uk/right-of-way-open-access-land/use-your-right-to-roam**). Nor do they apply if the landowner has given permission to access the land, which presumably is usually the case with hunts.

A similar piece of legislation, the Land Reform (Scotland) Act 2003, formalised the Scottish tradition of unhindered access to open countryside, provided that care is taken not to cause damage or interfere with activities including farming and game stalking. A person has access rights only if they are exercised responsibly, and conduct excluded from access rights includes being on or crossing land while responsible for a dog which is not under proper control (**https://www.legislation.gov.uk/asp/2003/2/part/1**).

Legislation and advice on dog fouling

Dog fouling is a devolved issue. In England and Wales, the system of controlling dog fouling under public spaces protection orders was introduced by the Anti-Social Behaviour, Crime and Policing Act 2014; this replaced the old system of dog control orders under the Clean Neighbourhoods and Environment Act 2005 (Defra, 2006). Dog owners have a legal duty to clean up after their dogs when they defecate in a public place. Some types of public land are exempt, including land used for agriculture or woodland, rural common land, land that is predominantly marshland, moor or heath, and highways with a speed limit of 50 mph or more. The laws that protect public rights of way (including public footpaths and bridleways) do not impose any rules about how dog owners should behave. In particular, there is no general legal requirement for dogs to be on a lead or under close control near livestock or in other sensitive situations (http://documents.hants.gov.uk/countryside/dogsonyourland.pdf).

Table 1. Some of the advice from leading countryside and dog-owning organisations on the disease risks posed by dogs in the countryside and how to minimise the risks

Organisation	Advice on responsible dog ownership
Countryside Council for Wales - https://www.forestry.gov.uk/pdf/eng-dogs-CCW-dogownerbooklet-English-05.pdf/$FILE/eng-dogs-CCW-dogownerbooklet-English-05.pdf	*You and your dog in the countryside* warns that dog mess can cause infections, so faeces should always be removed and disposed of responsibly. Make sure your dog is wormed every three months, to protect its own health and that of all other animals and your family. Keep your dog on a lead near farm animals, to prevent injury to them and your dog
The Kennel Club - https://www.thekennelclub.org.uk/our-resources/media-centre/issue-statements/dog-fouling/	Dog owners should always pick up after their dogs wherever they are in the wider countryside, except where there is advice to the contrary e.g. the Forestry Commission *Flick it off the path* posters. Not removing your dog's faeces can cause problems for farmers and livestock
National Farmers' Union - https://www.nfuonline.com/assets/30148	Their pamphlet *Enjoy the countryside responsibly with your dog* warns that dog faeces should be cleared up because they can spread disease to farm animals and, for the health of your pet and farm animals, prevent your dog from getting into water troughs and follow your vet's advice on worming
National Farmers' Union Scotland - www.hps.scot.nhs.uk/documents/ewr/pdf2017/1711.pdf; https://www.nfus.org.uk/news/news/nfus-poster-campaign-halves-dog-fouling-farmland	NFU Scotland urges people to clean up after their dogs when walking on or near to agricultural land because parasites found in some dog faeces can result in the abortions of cattle and death in sheep. Faeces from infected dogs can contaminate pasture, animal feed, water and bedding, and dog fouling undermines Scottish farmers' efforts to produce quality food and keep their livestock healthy. NFU Scotland asks dog owners to be responsible for the health of livestock
Natural England and Defra - https://www.gov.uk/government/publications/the-countryside-code	The *Countryside Code says* always ensure your dog does not disturb wildlife, farm animals or horses; that it does not stray off the path or area where you have a right of access; because of the risk of disease, always clean up after your dog and get rid of the mess responsibly; make sure your dog is wormed regularly to protect it, other animals and people
Scottish Natural Heritage - http://www.outdooraccess-scotland.com/sites/default/files//docs/dog_owners_leaflet.pdf; www.snh.gov.uk/docs/C233791.pdf	Dog faeces can carry diseases that can affect humans, farm animals and wildlife, so always clean up after your dog: infected dog waste left on grazing land can result in the death of sheep and abortion in cattle; keep your dog out of fields of vegetables or fruit, unless you are on a clear path, because of the risks of diseases in dog faeces being transmitted to people; do not take your dog into a field with lambs, calves and other young animals; keep your dog out of reservoirs and streams used to supply public water. The highest risks are in fields with livestock and where fruit and vegetables are growing, and in public open places such as along paths, tracks, riverbanks and loch shores

In Scotland, the Dog Fouling (Scotland) Act 2003 makes it an offence for a person in charge of a dog in a public open space not to clear up after their dog (**http://researchbriefings.parliament.uk/ResearchBriefing/Summary/CDP-2017-0081**). However, the Act does not apply to agricultural land (**http://www.environmentlaw.org.uk/rte.asp?id=50**); since 73% of the land in Scotland is agricultural, 5.6 million hectares are not covered by the Dog Fouling (Scotland) Act 2003. A recent survey showed that 65% of farmers felt that dog fouling was a problem on their land (Anon., 2015a), and it is an increasing problem for many farmers (**www.hps.scot.nhs.uk/documents/ewr/pdf2017/1711.pdf**). Dog faeces can affect the quality and safety of their crops and *Neospora* and *Sarcocystis* in faeces pose a risk to livestock (pages 29 and 30), and there is no effective way for farmers to control these diseases other than by limiting contamination of pasture and culling affected animals (**https://www.nfus.org.uk/news/news/nfus-poster-campaign-halves-dog-fouling-farmland**).

All major parasitic worms of dogs (excluding heartworm) are transmitted by the passage of eggs or larvae in faeces. So hygiene measures, especially cleaning up pet faeces regularly, will reduce environmental contamination with infective parasite stages and, alongside the use of anthelmintics, will make a significant contribution to the control of these parasites (**https://www.bsava.com/Resources/Veterinary-resources/Medicines-Guide/Antiparasitic-resistance**). However, since some dog owners are reluctant to clear up after their dog even when they are aware of the health and environmental consequences (Lowe *et al.*, 2014), stakeholders have called for a full review of the Dog Fouling (Scotland) Act 2003, including whether or not it should be extended to cover agricultural land (Anon., 2015a).

In the absence of any legal powers of enforcement, there is a great deal of advice from a diversity of countryside and dog-owning organisations about the disease risks posed by dogs in the countryside, and what people should do to reduce these risks (Table 1). All these organisations give comparable advice, and the main themes relevant to this review are: remove your dog's faeces and dispose of them responsibly; worm your dog regularly; keep dogs on a lead near livestock; do not allow dogs to drink out of livestock water troughs; keep your dog out of fields of vegetables and soft fruit; keep your dog out of fields with young livestock; and keep your dog away from bodies of water, especially those that may be used to supply drinking water. Much of this is not possible with a pack of free-running dogs, even though packs of hounds and working dogs fed on raw meat pose a far higher risk of disease transmission than pet dogs (page 20).

In Britain, dog owners are not currently required to clear up their pets' faeces from agricultural and most rural habitats, even though nearly half of outdoor visits in the UK included a dog, and one survey found that almost 40% of farmers had livestock that had suffered disease as a result of dog fouling. Dog fouling also poses a significant risk to vegetable crops and water courses that supply public water. There is pressure to extend the dog fouling legislation to include agricultural land and other rural habitats. However, it is impossible to collect faeces deposited by free-running packs of hounds, or restrict their access to fields with livestock or vegetable crops, or to prevent them drinking from water troughs

Biosecurity and hunting with hounds

Background

In 1981, for 60 of the 206 registered packs of foxhounds, mean size of their hunting countries was 732 square kilometres, with hunt countries largest in the midlands and east, and smallest in the north of Britain. On average there were 489 farmers in the area covered by a hunt, and 21.5% of the hunt's country was owned by hunting participants. Of the farmers in the hunt's country, 46 (9.4%) actually hunted, five banned the hunt from their land, and two discouraged the hunt from their land (Macdonald & Johnson, 1996).

Biosecurity advice is to restrict access of vehicles to areas where livestock graze, and ensure all vehicles are disinfected on arrival and before departure

Twenty years later, the Countryside Alliance reported that 272 of the 318 packs of hounds in England and Wales had a total registered hunting country of 346,000 square kilometres (133,600 square miles). Of this, 26% was not hunted for reasons of safety (motorways, roads, railways and development) and 3% because access was denied (https://web.archive.org/web/20041210021916/http://www.countryside-alliance.org:80/cfh/010517hfof.htm). Since the total land area of England and Wales (including urban areas) is only 151,140 square kilometres (58,355 square miles) (http://www.nationsencyclopedia.com/economies/Europe/United-Kingdom.html), the Countryside Alliance's figures are somewhat confusing. Presumably they do not take account of the fact the different types of hounds (such as beagles or harriers, foxhounds, minkhounds and staghounds) have overlapping countries. However, if an average of 29% of each hunt country is not hunted for safety reasons or because access is denied, hunts operated over around 70% of the rural land in England and Wales prior to the implementation of the Hunting Act 2004. Also, since hunts shared countries, much of rural Britain was hunted by more than one pack of hounds.

In the early 1980s, there were 80 followers on a typical day's foxhunting, with fifty mounted and the rest foot followers (Macdonald & Johnson, 1996), but the range was considerable, depending on the hunt and day of the week. In the late 1990s some of the larger hunts had 200 hundred mounted followers, although the number reduced as the day proceeded (Phelps *et al.*, 1997). Based on data collected in 2000, the Countryside Alliance found an average of 100 subscribers per hunt (based on 273 of the 318 registered hunts in England and Wales), and these 273 hunts held a total of 18,000 hunting days each season. Hunt supporters' clubs had an average of 170 members, and 87 non-members that were regular visitors (https://web.archive.org/web/20041210021916/http://www.countryside-alliance.org:80/cfh/010517hfof.htm).

The make-up of the hunting field was not well documented, although significant numbers of farmers and landowners participated (Burns *et al.*, 2000). In their submission to the Burns Inquiry, the Four Burrow Hunt for instance said that 29 of its 90 members were full time farmers (http://webarchive.nationalarchives.gov.uk/20080818111146/http://www.defra.gov.uk/rural/hunting/inquiry/evidence/hunts/fourburrow.htm).

In 2000, the Countryside Alliance estimated that the total annual attendance at the meets of the 318 packs of hounds in England and Wales was 1,280,000: of these, 541,000 people (42%) were mounted and 741,000 (58%) were on foot. Since a proportion of the people who attend meets do not go on to follow the day's hunting, it is unclear how many of these people spent some or all of the day following the hunt. Of the hunt followers, 64% lived in a village or rural situation, and 17% were agricultural workers (https://web.archive.org/web/20041210021916/http://www.countryside-alliance.org:80/cfh/010517hfof.htm; Orendi, 2012). So many followers and supporters travelled from a farm or estate to a hunt meet, often on another farm or estate.

A day's hunting

A day's hunting typically lasts from 11:00 to around 16:00. Having travelled to the meet, mounted followers unbox their horses, either on a roadside or a farm near, or at, the meet. Their horse box may be moved to another farm by a groom if the rider changes to a second horse part-way through the day, and it may be parked at another location to collect the horse(s) at the end of the day.

There will also be a number of hunt vehicles, usually quad bikes, but also 4WD vehicles, driving across farmland either laying trails, digging out foxes, or simply to follow the hunt. In 2000, 15% of hunt supporters followed the hunt on foot, 7.5% by car, 6% on motor bikes and 4% on bicycles (https://web.archive.org/web/20041210021916/http://www.countryside-alliance.org:80/cfh/010517hfof.htm). During the day the hounds will run some tens of miles across country and along roads and bridleways, the exact distance depending on how good the scent is that day (page 16). At various times during the day, those who follow on foot, motor bikes and bicycles go onto farmland using farm tracks and other access points to watch the hunt, and those who follow in cars may park their vehicles to walk across farmland to access a vantage point where they can observe the hunt.

So throughout a typical day's hunting, hounds, horses, people and vehicles will operate on a number of farms, sometimes in fields with livestock, and/or with livestock faeces, and/or fields that have been spread with animal-based manures that may contain a variety of infectious agents (page 8). At no point during the day is the hunt stopped for biosecurity measures before moving from one farm to the next. Nor are biosecurity measures in place before or at the end of the day's hunting, and once the day's hunting is over many of the participants will be returning to other farms or estates in the area.

Sporting visits

Hunts also regularly take their hounds, horses and vehicles on *sporting visits* to other hunts' countries, often some distance away, and these are becoming ever more popular (http://www.thefield.co.uk/hunting/hunt-visits-packing-visitors-32011), not least because, in recent years, kennel cough (infectious tracheobronchitis) has prevented many packs from hunting until the hounds recovered (page 15). The Eggesford Hunt, Exe Valley Buckhounds and Taunton Vale Harriers, for instance, were all affected in 2015 (Anon., 2015b), as were the Old Berkeley Beagles and the Cury Hunt the following year

(Anon., 2016a), and the Fernie Hunt, the United Hunt and the Woodland Pytchley Hunt the year after (Anon., 2017a). A few examples of sporting visits are shown in Box 4.

Box 4. Examples of some of the packs of foxhounds that operated in other hunt countries in recent years, mostly due to kennel cough or long-standing arrangements

When the Sinnington Hunt's hounds had kennel cough at the start of the 2016 season, the hounds from the Hurworth, Holderness, Bilsdale and Saltersgate Farmers Hunts all hunted in their country (Anon., 2016a)

When the Worcestershire Hunt's hounds missed a week due to a sneezing virus, the Clifton-on-Teme Hunt and North Ledbury Hunt hounds both hunted in their country (Anon., 2016b)

When the Vine and Craven Hunt were unable to take their hounds to the meet at Newbury Showground due to kennel cough, the Pytchley Hunt brought their hounds from Northamptonshire for a day in Berkshire (Anon., 2017b)

In October 2017 the Pennine Foxhounds made their 42nd visit to the west country to hunt in Cornwall and south Dartmoor: they were kennelled as usual with the Dartmoor Hunt and hunted in the countries of the Dart Vale and South Pool, Dartmoor, Lamerton, North Cornwall and South Devon Hunts (Fermor, 2017)

There is a long tradition of beagles hunting in other parts of the country, and even in Ireland. Until they were disbanded, the Curragh Beagles used to invite UK packs over to hunt. The Woodrock and Blackwater Beagles in County Cork hold an annual beagling festival in the first week of February. In 2013 it was the 30th year for the Chilmark and Clifton Foot Beagles; the other UK pack to be invited was the Old Berkeley Beagles, which were on their first visit. The Radley College Beagles were also invited to hunt in the Ballymacad Foxhound country (Green, 2013).

In Britain, the Norfolk Beagles Hound Club do not have their own hounds and other packs routinely hunt their country by invitation (https://en.wikipedia.org/wiki/List_of_beagle,_harrier_and_basset_packs_of_the_United_Kingdom). There are also a number of annual festivals where beagle packs attend from around the country. One of the largest was the Alston hare week, held annually in October until 2014 (https://www.huntsabs.org.uk/index.php/resources/92-news/press-releases/617-alston-hare-week-the-final-nail-in-the-coffin); other examples of joint beagling meets and festivals are given in Box 5.

Box 5. Examples of some of the packs of beagles that made sporting visits to other hunt countries in recent years

Alston and Northumberland Beagling Festivals held in October 2008 included the Black Combe, Chilmark and Clifton Foot, Newcastle and District, Pipewell, Old Berkeley, Pevensey Marsh, Stokesley, Weardale and Tees Valley, West Somerset and Wick and District Beagles (Humphreys, 2008)

Alston 2012 included the Britannia, Old Berkley Beagles (which had spent the previous week in Scotland), Stokesley Farmers, Stour Valley, Warwickshire and Weardale and Tees Valley Beagles (Heaton, 2012)

Alston 2013 included the Britannia, Chilmark and Clifton Foot, Stour Valley, Weardale and Tees Valley and West Somerset Beagles (Anon., 2013)

Goathland hunting week 2013 included the Ampleforth, Blean, Colne Valley, Hunsley Beacon, Stokesley Farmers and Stowe Beagles courtesy of the Norfolk Beagles Hound Club (Downds, 2013)

Northumberland is regularly visited by at least ten packs: in 2013 this included the Brighton Storrington Surrey and North Sussex, Derbyshire Nottinghamshire and Staffordshire, Newcastle and District, Old Berkeley, Pipewell and West Somerset Beagles (Lonsir, 2013)

The Cheshire Beagles hunted with the Warwickshire Beagles and in Yorkshire (Downds, 2015b)

The Dummer Beagles hunted at Carno, Montgomeryshire (Anon., 2008a)

Eton College Beagles visited the Dummer Beagles in Gloucestershire (Anon., 2010)

The Sandhurst and Aldershot Beagles hunted at Aberhosan, Machynlleth (Anon., 2008b)

The Weardale and Tees Valley Beagles hunted at Llangollen, Wrexham (Anon., 2008c)

Weather can also have an impact on the number of sporting visits: there was so little autumnal rain at the start of the 2015 season that every pack of lowland beagles that was able to do so went to hunt in upland areas to reduce the risk of their young hounds becoming lame on the hard ground in the lowlands (Downds, 2015a). All of these movements of packs of hounds around the country add to the risk of spreading diseases to new areas.

Biosecurity advice from the hunting organisations

Despite all the biosecurity advice from other countryside organisations, there is very little from the hunting organisations. The Countryside Alliance's *Guide to trail hunting* (http://www.countryside-alliance.org/countryside-alliance-guide-trail-hunting/) and their *Newcomer's guide to hunting* (http://www.countryside-alliance.org/ca-flatcap/wp-content/uploads/2016/04/Newcomers-Guide.pdf) make no reference to biosecurity issues.

Similarly, the Masters of Foxhounds Association's (MFHA) *Code of good hunting* (http://www.mfha.org.uk/about-the-mfha/codes-of-practice/26-code-of-good-hunting), which the MFHA issues on behalf of nine organisations, simply says *Never do anything that would be detrimental to agricultural interests*, but does not explain what this may be or make any specific reference to biosecurity. The advice hunting organisations give to their followers is focused on how to behave in the hunting field and etiquette, rather than how to minimise the risk of spreading disease from one farm to the next.

The biosecurity advice from a range of farming, veterinary and governmental organisations is very similar, and focuses on the need to avoid people and vehicles moving between farms without following careful disinfection procedures, the need to avoid transferring soil and faeces between farms, the importance of not sharing vehicles and equipment between farms, the importance of minimising the number of visitors to farms, the need to keep visitors away from livestock, and the disease risks posed by dogs having access to fields used for livestock and growing vegetable crops. These most basic biosecurity measures are ignored by hunts, and sporting visits to other parts of the country pose a significant risk of spreading diseases to new areas

Showing hounds at public events

Events attended by working hounds

Hounds interact with people, horses and other dogs brought to the meet at the start of a day's hunting. Hounds are also taken to a variety of events around the country where they interact directly and indirectly with other packs of hounds, livestock and a diversity of people of all ages.

There are seven hound shows at which packs of foxhounds are shown: Builth Wells, Honiton, Lowther, Peterborough, Rydal, the South of England Hound Show and The Great Yorkshire Show (Cairns, 2007). *Stackyard*, the online farming magazine, listed 148 major agricultural shows across the UK scheduled for 2018: hound displays were due to be included, or had been included in previous years, at 83 (56%) of these. Packs of hounds did not appear to be included at 63 (43%), and there was no information for two shows. Up to eight packs, with over 200 hounds, can be paraded together at agricultural shows, and provide *a rare opportunity for young people to mingle with the hounds* (Cairns, 2007). There are also a large number of country fairs, country shows and game fairs each year (http://www.ukcountryfairs.co.uk/), as well as fetes, hunt puppy shows and other events where

Children are at particular risk of infection from hounds

hounds are on display. Just a few hounds may taken to smaller events (Cairns, 2007).

According to the Countryside Alliance, hound parades are incredibly popular throughout the summer season and most hunts parade a number of times at various events (http://www.countryside-alliance.org/ashby-show-committee-votes-allow-hound-parades-massive-show-support/). So packs of hounds are attending several hundred, if not more, public events each year.

Biosecurity at animal gatherings

Anyone wanting to hold an animal gathering that includes cattle, deer, goats, pigs and sheep must have an Animal Gatherings Order (AGO) from the Animal and Plant Health Agency (APHA) (https://www.gov.uk/guidance/get-a-licence-to-hold-an-animal-gathering). A key condition of the AGO is that the licence holder takes all reasonable steps to prevent the spread of disease, and Animal Health (an executive agency of Defra) has published guidelines on biosecurity at animal gatherings. These include: good, clearly-identified facilities for people who handle animals to scrub and disinfect their boots when they go into and leave the animal area; washing their hands thoroughly; washing down any waterproof clothing; and safely disposing of any used disposable clothing. Organisers should provide facilities for cleansing and disinfecting vehicles and equipment that has been used in the animal rings and visitors should not come onto the premises with clothes or a vehicle contaminated with mud or other farm contamination (https://www.gov.uk/guidance/get-a-licence-to-hold-an-animal-gathering).

Basic biosecurity advice to farmers is that all livestock returning to the farm after a show should undergo quarantine procedures, and during this period: they should not share the same air space as the other animals; they should have a separate water supply; there should be separate equipment for quarantined stock; there should be a disinfection point outside the isolation area; staff should use separate protective clothing when in the isolation area; and staff should work with the quarantined animals last (http://www.xlvets.co.uk/farm/sites/xlfarmpublic.co.uk/files/uploads/files/97838-XL-Vets%20BioSecurity%20Cattle%20Booklet%20A5%2020pp.pdf).

The current biosecurity measures specifically apply to people who manage livestock, even though vehicles used to transport hounds to animal gatherings pose a comparable risk of disease transmission, both to animals and people at the event and to the other hounds in the pack on their return. However, few hunts have basic sick bay or quarantine facilities (Hobson, 1987), or follow other quarantine procedures when hounds return from agricultural shows and other public events.

Spread of diseases at animal shows

Although human-animal contact has many benefits, there are associated risks of human health problems. Between 1996 and 2010, there were approximately 150 human infectious disease outbreaks involving animals in public settings in the US (National Association of State Public Health Veterinarians, Inc., 2011). Infections with enteric bacteria and parasites pose the highest risk because animal fur, hair, skin and saliva harbour faecal organisms, and so transmission can occur when people pet, touch, feed, or are licked by animals. Key risk factors are direct animal contact and inadequate hand washing. Children are at particular risk because of their immature immune systems and poor hygiene, and the risks of transmission are enhanced when hand-washing and other facilities are not available (National Association of State Public Health Veterinarians, Inc., 2011). As one example, the low number of *Toxocara canis* eggs in soil and the relatively high numbers on the fur of dogs suggest that direct contact with dogs may be more important in the epidemiology of human toxocariasis than soil contamination (Wolfe & Wright, 2003). The MFHA of America recognises the risk of disease transmission between hounds and children and stress the importance of keeping their hounds healthy (Seier & Foster, 2015).

In addition to the risks of hounds transmitting disease between sites and livestock, and people and any dogs they may have bought to the show, there is also a significant risk of transmission between packs of hounds. Kennel cough is a highly contagious canine respiratory disease caused by a number of different bacteria and viruses, normally a combination: two of the commonest causative organisms are *Bordetella bronchiseptica* and canine parainfluenza virus (http://www.pethealthnetwork.com/dog-health/dog-diseases-conditions-a-z/kennel-cough-signs-and-symptoms). An outbreak of kennel cough in hounds in 2013 meant that the MFHA and the organisers of the Peterborough Festival of Hunting, the leading hound show, had to exclude any pack of hounds that had been at the Great Yorkshire Show that year because kennel cough had been confirmed in a pack that showed there (http://www.horseandhound.co.uk/hunting/kennel-cough-keeps-hunts-away-from-peterborough-royal-foxhound-show-399109).

Despite these measures, other packs of hounds picked up kennel cough that year on the hound show circuit (http://www.horseandhound.co.uk/forums/showthread.php?677209-Kennel-Cough-any-experiences). In 2015, kennel cough meant that only 13 packs showed at Peterborough out of the 21 entered (Anon., 2015b). In 2017 *Horse & Hound* reported a dwindling support for the major hound shows, in part due to the risks of contracting kennel cough (https://www.pressreader.com/uk/horse-hound/20171102/282166471444660).

Similarly, one of the factors contributing to the spread of visceral leishmaniosis over a large part of the eastern US and Canada was that packs of foxhounds from different parts of the country attended joint meets and events (Anon., 2001).

While there are benefits of human/animal contact at agricultural shows and other events, there is also a significant risk of disease transmission, both between animals and humans at the event, and between locations. Biosecurity advice issued by Animal Health for licensed animal gatherings currently only apply to livestock, but basic biosecurity advice during the event and on quarantining livestock returning from a show are equally relevant to packs of hounds. The spread of kennel cough in Britain and visceral leishmaniosis in North America illustrate the risks that hounds attending events will spread diseases to new parts of the country

Feeding hounds

Energy requirements of hounds

There are no quantified data on the distance travelled by hounds each day. Prior to the use of hound vans, one Master of Foxhounds (MFH) estimated that a foxhound would jog 12 miles to the meet, was drawing or hunting for around five hours and would then walk 8 miles or so home. On this basis, he estimated that a hound would be out for 8.5 to 9 hours and would travel at least 30 to 40 miles on a bad day, but 50 to 60 miles on a good scenting day, when hounds were running hard most of the day (Barclay, 1946). Another MFH suggested that hounds are capable of running up to 70 miles in a day (Beaufort, 1980). Whatever the accuracy of these estimates, it is clear that hounds travel long distances when hunting, and both the distance and speed travelled depend on the scenting conditions that day.

The maintenance energy requirement (MER) is the energy required by a moderately active adult dog at the optimal ambient temperature to maintain body weight, but not support growth, pregnancy or lactation: estimates of the MER for inactive pet dogs of the same weights as different breeds of hounds are shown in Table 2. The MFHA of America give slightly higher MERs for foxhounds, suggesting 1710 kcal for a 30 kg (66 lbs) foxhound and 2110 kcal for a 40 kg (88 lbs) foxhound. On hunting days, foxhounds may require two to three times more energy than their MER (Daniels & Haight, 1975; Cline & Reynolds, 2005). As a rough calculation, when hunting, foxhounds require 0.8 k/cal (kilocalories) per pound of body weight per mile travelled (Seier & Foster, 2015) or over 4000 kcal on a typical hunting day (**https://www.totallyvets.co.nz/search,portfarticle,23,,662,Feeding+working+dogs.html**). Supplying this amount of energy for hounds during the hunting season can cause practical problems.

Table 2. Typical weight ranges of different hounds (Fogle, 2000) and the maintenance energy requirement (MER) for an inactive pet dog of the same weight (**https://thebark.com/rer/pdf/MER-Adult-Dogs.pdf**)

	Weight - kilograms	Weight - pounds	MER - kcal/day
Basset hound	18 - 27	40 - 60	830 - 1125
Beagle	8 - 14	18 - 30	452 - 688
Bloodhound	36 - 50	80 - 110	1396 - 1786
English foxhound	25 - 34	55 - 75	1062 - 1338
Harrier	22 - 27	48 - 60	965 - 1125
Otterhound	30 - 55	65 - 120	1218 - 1919

Dogs are more efficient at fat metabolism than most other species, and fat has about 2.5 times more energy per gram than either protein or carbohydrate. An appropriate diet for hounds should provide approximately 25% of the calories from protein, 30% from fat, and 45% from carbohydrates (Cline & Reynolds, 2005). Because of the differing digestibility of the various components, hunt season diets should be 30% protein and 27% fat but, to save costs, off season diets can be reduced to 23-24% protein and 10-15% fat (Seier & Foster, 2015).

Diet digestibility should be at least 80% to promote adequate uptake of the nutrients without excess faecal bulk. The more energy dense the food, the less voluminous the stool (Cline & Reynolds, 2005). As a rough guide, because of the difference in energy content, a dog must consume one-third more dry matter in the form of cereal than meat for the same amount of work and, because of the difference in digestibility, cereals have to be cooked before feeding to dogs (Daniels & Haight, 1975). So cereal-based diets are usually fed in the form of a cooked porridge that is allowed to cool until it becomes a solid pudding. This is generally made a day in advance, and fed to hounds in a trough mixed with chopped cooked meat and some of the broth in which the meat has been cooked. However, feeding cooked foods is more time-consuming and involves a lot more for work hunt staff

to prepare than if the hounds are fed raw flesh (Cook, 1826; Jones, 1989). Also, raw flesh takes much longer to go through a hound than cooked meat mixed into a porridge or cereal diet (Banta *et al.*, 1979; Beaufort, 1980), and so hounds need to be fed far less often when their diet is predominantly raw flesh (Beaufort, 1980).

Changes in feeding practices

From the mediaeval period to a peak in the 18th century, horse meat was the preferred food for hounds (Wilson & Edwards, 1993). However, it was stressed to huntsmen that it was important to beware of the vendor from whom horseflesh was purchased, and to boil the meat before feeding it to hounds, since any disease a horse may have died from could be passed on to the dogs (Cook, 1826).

Thereafter, until the start of the Second World War, hounds were primarily fed on boiled horse flesh mixed with oatmeal and vegetables (Colville, 1940; Higginson, 1948). For reasons of economy, rice was often substituted for oatmeal in the summer (Shepherd, 1936). However, some beaglers preferred to give the flesh to hounds raw. Carcases were cut into small pieces or skinned, quartered and thrown, uncooked, to hounds; the latter ensured that the beagles were unable to gorge (Paget, 1931; Lloyd, 1954; Hobson, 1987).

The Second World War ended the use of oatmeal for animal feeding, and fuel and labour costs meant that most hunts started to feed their hounds on raw flesh (Lloyd, 1954; Thompson & Smyth, 1975; Lett, 2013), even though the risks had long been recognised. Section 6 of the Dogs Act 1906, for instance, made it an offence for *Any person who shall knowingly and without reasonable excuse permit the carcase of any head of cattle belonging to him to remain unburied in a field or other place to which dogs can gain access shall be liable on conviction under the Summary Jurisdiction Acts to a fine not exceeding forty shillings*. Section 7 of the Dogs Act 1906 defined *cattle* as including *horses, mules, asses, sheep, goats, and swine*. This measure was introduced to prevent the spread of parasites, particularly tapeworms, associated with dogs eating raw meat (pages 35 and 36). For this reason, hunts were recommended to establish the cause of death of any animal, particularly if it was to be fed raw to the hounds. If death was from disease, or there was any doubt about the cause of death, it should be cooked (Lloyd, 1954).

In the mid-1970s, a questionnaire was sent to all the 353 registered hunt kennels in Great Britain (203 foxhounds, 83 beagles, 26 harriers, 16 otterhounds, 12 basset hounds, six drag hunts, four staghounds and three blood-hounds): half responded. Of the larger packs (foxhounds, harriers and staghounds), 34% fed just raw meat, 14% only used cooked meat, and 52% used a combination of raw and cooked meat, sometimes with added cereal. However, where the meat was cooked, the cooking was rarely adequate to sterilise the meat. For the smaller packs (basset hounds, beagles, bloodhounds, drag-hounds and otterhounds), the figures were 24.6%, 10.5% and 64.8%, respectively. Very little sheep meat was used, except by smaller hunts, which had to use what they could get. In Scotland few horses were fed to hounds, generally not more than five times a year, whereas in the rest of Great Britain horse meat was fed as frequently as once a fortnight, and sometimes once a week. The ma-jority of hunts which fed raw meat also fed the offal raw, and very often the liver and lungs were not removed from the carcase, which was fed directly to the hounds. Very few hunts rejected cystic livers or lungs, which were reportedly relished by the hounds (Thompson & Smyth, 1975). During this period most hunts were able to obtain adequate supplies of raw flesh, although the Duke of Beaufort's Hunt found this difficult to come by, and so used flaked wheat scalded the night before, mixed with thoroughly boned meat that had been chopped up and cooked the previous day (Beaufort, 1980).

Most hunts today continue to feed raw flesh to their hounds (page 25). For hunts that use dried food to feed their hounds, either instead of, or as a supplement to, raw flesh, several different commercial dried foods are now available (e.g. **https://www.cobbydog.com/**; **www.crystalfeeds.co.uk**), and these avoid the need for cooking. The working hound meal produced by Target Feeds, for example, is described as *a fully cooked, highly digestible meal designed to be fed either as the sole complete maintenance and working diet or at lower feeding rates as a flesh balancer when flesh is short* (**https://www.targetfeeds.com/hounds.html**).

The MFHA of America recommend that, if dry food is fed, the highest quality dry food should be used i.e. it should have the highest protein and fat percentages that the hunt can afford, and that the amount that is fed should be varied according to the work level of the hounds. They also advise that, if flesh is fed, only good meat must be used (Foster & Wood, 2015). However, these commercial feeds are expensive, and some UK hunts seem to be using a variety of human food items to feed their hounds (e.g. Barker, 2010a, 2011).

Feeding hounds on hunting days

Hunts try to ensure that their hounds hunt on an empty stomach. In the mid-1800s, hounds were typically fed around 11:00 so that they would have 24 hours before they started hunting and be *sharp set* (Scrutator, 1858). Withholding food for approximately 24 hours before a period of intense exercise also helps alleviate problems associated with a full colon (Koehn, 1942; Cline & Reynolds, 2005).

Although practices vary between hunts, foxhounds are now usually fed earlier in the day. Foxhounds that meet at 11:00 are usually fed the previous day about 08:00

but 24 hours from the time of feeding to the time of meeting is probably sufficient for beagles which, for their size, have a more strenuous day than foxhounds (Paget, 1931). The Duke of Beaufort's hounds that were not hunting were typically fed at 07:00, but those that were hunting would not be fed until they came in, and so would have been up to 36 hours without food to ensure that their stomachs really were empty (Beaufort, 1980).

Mean whole gut transit time (WGTT) in dogs ranged from 19 to 34 hours (Rolfe *et al.*, 2002). In a range of dogs of different sizes, stomach emptying time ranged from 6 hours 45 minutes to 14 hours 57 minutes, and WGTT ranged from 21 hours 34 minutes to 57 hours 23 minutes (Boillat *et al.*, 2010). Thus hounds that have had food withheld for 24 hours will have an empty stomach, but most of the food will not have been passed, especially if they were fed raw flesh.

Because their guts are not empty, hounds defecate during a day's hunting, but how often is unclear: a healthy dog will normally defecate a couple of times a day. The amount of faeces produced is variable: a dog fed a predominantly cereal as opposed to a meat diet has to eliminate over 2.5 times as much dry matter in faeces (Daniels & Haight, 1975). Larger breeds of dogs typically produce more soft stools when fed a diet rich in offal or other meat protein and connective tissues (Zentek & Meyer, 1995).

Exercise is a heat-producing activity and about 60% of the heat dissipated by exercising dogs is through water evaporation in the respiratory tract. So a plentiful supply of water is important to remove the by-products of energy metabolism, and dogs should be actively encouraged to drink water during extended periods of exercise (Cline & Reynolds, 2005). However, hunts rarely provide water for their hounds when they are in the field, and they typically drink from natural water sources and livestock drinking troughs, particularly on warm days, even though ingesting untreated water from lakes, rivers and streams are significant risk factors for dogs infecting humans with *Campylobacter* (Adak *et al.*, 1995), and allowing dogs access to livestock water troughs poses a significant risk to livestock (https://www.nfuonline.com/assets/30148).

Giardiosis, a diarrheal disease caused by *Giardia lamblia*, is also on concern. The parasite survives in contaminated water; 21% of UK dogs are infected and over 3500 human cases are reported in England and Wales each year, although many cases go undiagnosed. Key to preventing transmission is for dogs to be provided with clean drinking water rather than allowing them to rely on environmental sources (https://www.healthline.com/health/giardiasis; https://www.nhs.uk/conditions/giardiasis/; Baneth *et al.*, 2016).

Hounds require a high-energy diet, especially during the hunting season. Prior to the Second World War, most hunts fed their hounds on a porridge pudding with cooked meat added, but restrictions on using oats to feed animals and rising fuel and labour costs meant that most hunts now rely mainly on raw flesh. Some hunts use commercial dried foods, either exclusively or to supplement a raw flesh diet, and some hunts also use unwanted human food items. While hounds are not fed for around 24-hours before hunting, gut passage times mean that they are still likely to defecate when out hunting. Hounds require a lot of water when active: hunts typically do not supply water for their hounds when hunting, so they drink at natural water sources and livestock water troughs, despite the associated biosecurity risks

Health risks of feeding raw meat to dogs

The risks to companion animals

Because of the inherent risks of eating animals that have died of, or were weakened by, disease, scavengers and species such as wolves (the ancestors of dogs) that are both predators and scavengers as circumstances prevail (Mattisson *et al.*, 2016), have significantly higher stomach acidities to help protect them from the foreign microbes in their food (Beasley *et al.*, 2015). However, the acidity of a dog's stomach is only a partial barrier to microbes.

There is an increasing trend to feed BARF diets (variously taken to mean Biologically appropriate raw food or Bones and raw food) to pet dogs. The meat included in commercially-available diets is human-grade, but pets are also fed on meat and offal from a variety of sources. The health risks of feeding raw meat to pet dogs (whatever the source) are well established. In North America, the American Animal Hospital Association, American Veterinary Medical Association (AVMA) and the Canadian Veterinary Medical Association have issued statements discouraging the inclusion of raw or undercooked animal-source protein in dog diets (Freeman *et al.*, 2013). Because of the risk of illness to both companion animals and humans, the AVMA discourages feeding dogs with any animal-source protein that has not first been subjected to a process to eliminate pathogens (https://www.avma.org/KB/Policies/Pages/Raw-or-Undercooked-Animal-Source-Protein-in-Cat-and-Dog-Diets.aspx).

There is a significant health risk of allowing people to interact with hounds fed raw meat and offal from fallen stock

Similar advice is given by the British Veterinary Association (BVA). In a policy brief issued on 12th October 2005, they advised against feeding raw meat or bones to companion animals because of the risk of infection with pathogens such as *Campylobacter*, *Clostridium*, *Escherichia coli*, *Listeria*, *Salmonella* and norovirus (**http://www.bmj.com/rapid-response/2011/10/31/british-veterinary-association-policy-brief**). These pathogens pose a substantial risk of infectious disease for the pet, the pet's environment, and the people in the household (Schlesinger & Joffe, 2011; Waters, 2017). The BVA issued a subsequent statement on 31st January 2014 confirming that, while raw food diets are increasingly popular for dogs, it can be difficult to ensure that they are safe (**https://www.bva.co.uk/news-campaigns-and-policy/newsroom/news-releases/bva-comment-on-dog-food-in-the-media/**).

In England and Wales, occupational exposure to raw meat and having a household with a pet with diarrhoea were significant risk factors for infection with *Campylobacter* (Adak *et al.*, 1995). Campylobacteriosis is the most frequently reported notifiable human enteric infection in the United States, and a large proportion of the dogs infected with *Campylobacter* excrete bacteria in their faeces without showing symptoms (LeJeune & Hancock, 2001). Canine faeces are a potential reservoir for *Escherichia coli* and avoiding feeding raw meat to pet dogs may reduce the chance of humans becoming infected (Naziri *et al.*, 2016). In the UK, a significantly higher seroprevalence for *Toxoplasma* in women was associated with feeding a dog raw meat (Nash *et al.*, 2005).

However, the biggest threat is *Salmonella*. It causes the most hospital admissions and around 200 deaths per year in the UK and can only be killed by heat (Waters, 2017). In the US, *Salmonella* spp. are estimated to cause about 1.4 million non-typhoidal infections in humans per year; of these about 15,000 cases require hospitalisation, and over 400 people die (Doyle *et al.*, 2009). Being fed a commercial or homemade raw diet or a homemade cooked diet increases a pet dog's risk of being infected with *Salmonella* (Leonard *et al.*, 2011). Healthy dogs can became infected with *Salmonella* after a single meal (Finley, 2004), and standard methods of cleaning and disinfection are minimally effective at eliminating *Salmonella* contamination of food bowls (Weese & Rousseau, 2006). A large proportion of infected dogs become carriers, excreting organisms in their faeces without showing symptoms (LeJeune & Hancock, 2001), thereby contaminating the household and wider environment, and potentially infecting people and other animals (**https://www.avma.org/KB/Resources/FAQs/Pages/Raw-Pet-Foods-and-the-AVMA-Policy-FAQ.aspx** Finley *et al.*, 2006, 2007).

Feeding meat that had not been cooked properly, particularly meat unfit for human consumption, was thought to have contributed to widespread *Salmonella*

infection in greyhounds at a breeding facility and extensive environmental contamination. Husbandry factors such as commingling groups of young dogs, failure to separate or isolate sick or newly introduced dogs, and limited use of hand hygiene procedures after handling food or faeces, or between handling dogs from different groups, contributed to the spread of *Salmonella enterica* throughout the kennels (Morley *et al.*, 2006).

Similarly, 14 out of 45 dogs in a Swedish kennel died during an outbreak of Aujeszky's disease (pseudorabies). The source of the infection was abattoir offal (throats, lungs and livers from pig) stored frozen at -25 to -35°C for up to six weeks before being thawed and fed raw to the dogs. None of the 15 dogs in a separate part of the kennels, where the offal was always cooked before being fed to the dogs, contracted the disease (Hugoson & Rockborn, 1972).

Alabama rot (idiopathic cutaneous and renal glomerular vasculopathy) is a mysterious disease first identified in greyhounds in Alabama in the 1980s, and in Britain in November 2012. It is still rare, but cases are widespread. While the cause is currently unknown, one suggestion is that Alabama rot is due to toxins from bacteria in raw meat eaten by the dogs (**http://www.countryfile.com/news/alabama-rot-dog-disease-what-you-need-know**; **www.vets4pets.com/stop-alabama-rot/**; **http://www.telegraph.co.uk/news/health/pets-health/10731896/Raw-meat-could-be-cause-of-dead-dogs-scientist-warns.html**; Holm *et al.*, 2015).

The risks to working dogs

While the risk of food-borne illnesses in pet dogs, particularly those fed on a BARF diet, is a major concern, the risks to working dogs are more significant when they are fed the carcases of fallen stock. The problem was highlighted by a retired huntsman, who cautioned that, when you *receive cattle or sheep, you do not know what the vet has been treating them with or what infections they have had. You have to feed what you have* (Barker, 2010b). There is a significant risk of disease transmission to the hounds (page 28), as well as the risk of introducing or perpetuating diseases in livestock populations (LeJeune & Hancock, 2001).

The two diseases that are a major concern to farmers are neosporosis in cattle and sarcocystosis in sheep. Both can be picked up by dogs which eat infected placenta/foetal material, or raw meat from infected stock. To minimise the risk of picking up the parasites, dogs, including farm dogs, should not be allowed to eat material from fallen stock, or other material such as placentas or foetal material. Prompt disposal of carcases and any other potentially contaminated material will help to limit the spread of disease, and farm dogs should not be allowed to defecate in grazing fields (**http://www.outdooraccess-scotland.com/sites/default/files//docs/risk_of_the_spread_of_disease_in_livestock_from_dog_faeces_-_briefing_note_for_access_authorities_0.pdf**).

Feeding raw meat to dogs that have contact with livestock also poses risks due to the possibility of infection with parasitic cestodes (tapeworms). *Taenia hydatigena* and *Taenia ovis* develop in the liver or muscle of their intermediate hosts and cause cysticercosis in livestock; their life cycle is completed by feeding infected meat or organs to dogs, which then contaminate the environment with eggs that are infectious to livestock. Similarly, *Echinococcus granulosus* is transmitted from dogs to cattle, goats, pigs and sheep via their faeces (**https://www.cdc.gov/parasites/echinococcosis/biology.html**; LeJeune & Hancock, 2001). People can become infected with echinococcosis by direct contact with dogs (their fur can be contaminated with eggs), or by ingesting soil, water or vegetables contaminated by dog faeces (**https://www.cdc.gov/parasites/echinococcosis/gen_info/ce-faqs.html**). Not allowing a dog to eat raw meat from cattle, goats, pigs and sheep prevents the dog from becoming infected (**https://www.cdc.gov/parasites/echinococcosis/gen_info/ce-faqs.html**), and farmers/land managers should remove any raw livestock matter, such as an aborted foetus, the placenta of a newly born calf/lamb, or fallen stock, promptly to make sure that dogs cannot access or eat it (**http://www.outdooraccess-scotland.com/sites/default/files//docs/risk_of_the_spread_of_disease_in_livestock_from_dog_faeces_-_briefing_note_for_access_authorities_0.pdf**).

While the cornerstone of preventing toxocariasis in humans is minimizing the environmental contamination with (infective) eggs by rigorous removal of faeces and by treatment of infected dogs and cats, other preventive measures include avoiding transmission by feeding of raw liver or offal (Baneth *et al.*, 2016).

A number of veterinary organisations have issued advice urging people not to feed raw meat to dogs because of the health risks to the dogs and the risks of disease transmission to humans. Raw meat can carry a number of life-threatening pathogens, and dogs can excrete some of these pathogens without showing any symptoms. Feeding raw meat diets to working and other dogs in contact with livestock perpetuates a number of costly livestock diseases

Collection of fallen stock by hunts

Routine mortality of animals is an inevitable consequence of livestock farming, and modern farming systems generate a significant number of fallen stock that need to be disposed of safely, practically and economically (Gwyther *et al.*, 2011). Fallen stock includes dead animals and condemned materials from any animal that has died of natural causes or disease on a farm or that has been killed on a farm for reasons other than for human consumption, and so fallen stock may contain a wide variety of chemical contaminants and/or biological agents (**http://www.gov.scot/Topics/farmingrural/Agriculture/animal-welfare/ABPs/fallenstock**; EU Scientific Steering Committee, 1999).

Changes in legislation

To try to control the use of raw meat that was not fit for human consumption, the Meat (Sterilization) Regulations 1969 required that knackers' yards were licensed and inspected by local authorities. While these Regulations prevented hunt kennels from getting raw meat from a knacker's yard or slaughterhouse, they were viewed as a service rather than a trade and so hunt kennels were unlicensed and could still obtain fallen stock or casualty animals directly from farmers. So the flesh of fallen stock continued to be fed to hounds and the left-overs and unusable offal sold to renderers to produce fertilisers and animal feed (Anon., 1993). A contemporary report on echinococcosis in Wales described this as a loophole in the Regulations (Williams, 1982).

The Meat (Sterilization) Regulations 1969 were revoked by the Meat (Sterilisation and Staining) Regulations 1982 as amended (there were similar regulations in Scotland

Fallen stock should not be accessible to wild animals or necrophagous birds and not left uncovered as in this hunt kennel

and Northern Ireland), which also restricted the use of meat not fit for human consumption. Stained but not sterilised meat could, for instance, only be moved from a knacker's yard to a zoological garden, menagerie, fur farm, maggot farm or greyhound kennels. Again, these regulations did not apply to hunt kennels.

The discovery of bovine spongiform encephalopathy (BSE) in the UK in 1986 led to a number of new regulations being introduced, such as the Bovine Offal (Prohibition) Regulations 1989, the Bovine Spongiform Encephalopathy Order 1991, the Specified Bovine Offal Order 1995 and the Specified Bovine Material Order 1996 as amended (www.food.gov.uk/bse/what/beef/controls; http://www.hse.gov.uk/pubns/web22.pdf; www.defra.gov.uk/animalh/bse/legislation/index.html). The aim was to prevent high risk parts of cattle, referred to as specified bovine offal (SBO) and, subsequently, specified risk materials (SRMs), from entering the animal and human food chain. The high-risk materials included the brain, spinal cord, spleen, thymus, tonsils and intestines of a bovine animal six months old or over which had died, or been slaughtered, in the UK, and the thymus and intestines of younger animals. After November 1990 no SBO should have been fed to hounds (or any other animal). However, Richard Packer, the Permanent Secretary at MAFF (now Defra) from 1993 to 2000, reported that, as late as 1995, this provision was not always complied with (Packer, 2006).

The BSE restrictions increased the running costs of hunts by several thousand pounds a year if they had to pay renders to dispose of unwanted materials (Anon., 1993). For hunts without their own incinerator, the cost of removal was around £150 per tonne. In the early 1990s the BSE regulations were costing the Chiddingfold, Leconfield & Cowdray Hunt £8000 to £12,000 per annum for disposal of offal. Prior to BSE, the collection of fallen stock cost the Berkeley Hunt £15,000 per annum and, following BSE, the disposal of unwanted animal material cost the hunt an additional £16,500 per annum. As a consequence, hunts started to ask farmers who allowed them to hunt on their land for a voluntary donation for collection of fallen stock, and had a set rate of charges for other livestock owners (Anon., 1993). In 1997 the MFHA estimated that the cost of providing a dead stock service was £15,000 for a Northumberland hunt, £24,000 for a Gloucestershire Hunt, £27,000 for a Buckinghamshire Hunt and £49,000 for a Northamptonshire Hunt (http://webarchive.national-archives.gov.uk/20080726235540/http://www.hunting-inquiry.gov.uk/mainsections/huntingframe.htm).

The food crises of the 1990s highlighted the part played by animal by-products not intended for human consumption in the spread of infectious diseases, and on 1st July 2001 the Government brought in new regulations to comply with European rules aimed at combating the spread of BSE. These required that all cattle over 30 months that died or had to be put down were disposed of by Government employees. However, there were too few staff available to deal with all the carcases and, since BSE was the priority, in September 2001 Defra announced that hunt kennels were being used to reduce the backlog of bTB reactors on farms. Hunts were being paid £120 per animal, including mileage, for the humane destruction of reactors, the transportation of carcases, the preparation of the carcase for *post mortem* examination at the kennels, and disposal of the carcase including SRMs. Defra's justification for this policy was that cattle with bTB were not technically fallen stock under the new regulations, so using hunts was not in contravention of the rules (http://www.telegraph.co.uk/news/uknews/1340003/Officials-break-rules-as-hunts-cull-TB-cattle.html).

To limit the risk of pathogens and infective agents entering the animal feed chain, the European Union (EU) Animal By-Product Regulations (1774/2002) of 3rd October 2002 laid down health rules concerning animal by-products not intended for human consumption. This restricted the disposal of fallen stock to incineration (either on or off-farm), rendering, high temperature/pressure alkaline hydrolysis, disposal at maggot farms or through licensed waste collectors (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:f81001; Anon., 2002). The amended EU Animal By-Products Regulation (1069/2009) came into effect in March 2011.

Burying fallen stock was banned in all EU member states in 2003 to protect the health of humans and animals and safeguard the environment. While farmers cannot routinely burn or bury fallen stock on their farm, there are exceptions for remote areas (https://www.gov.uk/guidance/fallen-stock; http://www.gov.scot/Publications/2003/08/18059/25737). The regulations do not apply to pets; in England all horses can be buried, whereas only pet horses can be buried in Scotland, Wales and Northern Ireland (https://www.gov.uk/guidance/fallen-stock; https://www.daera-ni.gov.uk/articles/fallen-stock-guidance). When asked by the National Fallen Stock Company (NFSCo), 15% of owners had their horse's body taken by the local hunt (https://www.beva.org.uk/Home/News-Archive/entryid/403/Owners-experiences-of-equine-euthanasia-or-death).

Disposal of fallen stock

There is no requirement to establish the cause of death for fallen stock, but owners are required to contact their local APHA immediately if they believe that an animal has died of a notifiable disease (see Table 3) (http://www.gov.scot/Topics/farmingrural/Agriculture/animal-welfare/ABPs/fallenstock). All EU member states are also required to carry out active disease surveillance for BSE in cattle and scrapie in sheep and goats to determine the transmissible spongiform encephalopathy (TSE) disease status of each country. Thus fallen cattle over 48 months old must be tested for BSE at an approved sampling site (http://www.gov.scot/Topics/farmingrural/Agriculture/animal-welfare/ABPs/fallenstock).

Table 3. List of notifiable animal diseases i.e. diseases that must legally be reported to the Animal and Plant Health Agency (APHA), even if it is only suspected that an animal may be affected (**https://www.gov.uk/government/collections/notifiable-diseases-in-animals**); additional data from **http://www.gov.scot/Topics/farmingrural/Agriculture/animal-welfare/Diseases/disease/notifiable**

Disease	Hosts	Last GB record	Disease	Hosts	Last GB record
African horse sickness	Horses	Never	**Equine viral arteritis**	Horses	2010
African swine fever	Pigs	Never	**Foot and mouth disease**	Cattle, pigs, sheep, other cloven hoofed mammals	2007
Anthrax	Cattle, other mammals	Present	**Glanders and farcy**	Horses	1928
Aujeszky's disease	Pigs, other mammals	1989	**Goat plague**	Goats, sheep	Never
Avian influenza	Poultry	2016	**Lumpy skin disease**	Cattle	Never
Bovine spongiform encephalopathy	Cattle	Present	**Newcastle disease**	Poultry	2006
Bluetongue	Cattle, goats, sheep	2007	**Paramyxovirus infection**	Pigeons	Present
Bovine tuberculosis	Cattle, deer, other mammals	Present	**Porcine epidemic diarrhoea**	Pigs	2002
Brucellosis	Cattle	2004	**Rabies**	Dogs, other mammals	2006
Chronic wasting disease	Deer	Never	**Rabies in bats**	Daubenton's bats	2017
Classical swine fever	Pigs	2000	**Rift Valley fever**	Cattle, goats, sheep	Never
Contagious agalactia	Goats, sheep	Never	**Rinderpest**	Cattle	1877
Contagious bovine pleuro-pneumonia	Cattle	1898	**Scrapie**	Goats, sheep	Present
Contagious epididymitis	Goats, sheep	Never	**Sheep and goat pox**	Sheep	1866
Contagious equine metritis	Horses	2012	**Sheep scab** (notifiable in Scotland only)	Sheep	Present
Dourine	Horses	Never	**Swine vesicular disease**	Pigs	1892
Enzootic bovine leukosis	Cattle	1996	**Teschen disease**	Pigs	Never
Epizootic haemorrhagic disease	Deer	Never	**Vesicular stomatitis**	Cattle, horses, pigs	Never
Epizootic lymphangitis	Horses	1906	**Warble fly**	Cattle, deer, horses	1990
Equine infectious anaemia	Horses	2012	**West Nile fever**	Horses	Never

All other fallen stock must be collected, identified and transported to an approved premise (https://www.gov.uk/government/publications/animal-by-product-operating-plants-approved-premises) as soon as reasonably practical under the circumstances, usually within 48 hours of death. Because of the disease risk, fallen stock must not be fed to red kites or necrophagous birds (birds that feed on carcases), and animals and birds must not be able to access fallen stock prior to collection (https://www.gov.uk/guidance/fallen-stock; http://www.gov.scot/Publications/2005/03/20613/51366; https://www.daera-ni.gov.uk/articles/fallen-stock-guidance).

EU Animal By-Products Regulation (1069/2009) recognises three categories of animal by-products (ABPs). Category 1 ABPs are classed as very high risk and include carcases and all body parts of animals suspected of being infected with TSE and SRMs. Category 2 ABPs are classed as high risk and include animals rejected from abattoirs due to having infectious diseases and carcases of dead livestock. Category 3 ABPs are classed as low risk and include hides and skins from slaughterhouses and animal hides, skins, hooves, feathers, wool, horns, and hair that had no signs of infectious disease at death. Any site that collects and treats ABPs to be used as feed is considered to be a collection centre; category 2 and 3 ABPs can be treated at collection centres, and these sites must have facilities to destroy unused ABPs or send them to an approved processing, incineration, or co-incineration plant to be destroyed (https://www.gov.uk/guidance/collecting-and-treating-animal-by-products-at-collection-centres).

The level of compliance with the Regulations is unclear. During 2008 and 2009 aborted foetuses/stillborn animals were being disposed of illegally by 19.5% of British farmers who responded to a survey and placentas by 57.6%. Overall, 13.7% of respondents used a variety of illegal disposal methods for fallen livestock carcases and other ABPs. Beef farmers were the most likely to dispose of placentas illegally, followed by dairy farmers and sheep farmers. Illegal disposal of potentially infectious material could increase disease transmission, including *Campylobacter* species, enzootic (chlamydial) abortion, scrapie and brucellosis (Cullen, 1991). This is of particular concern since brucellosis, *Campylobacter* species and enzootic (chlamydial) abortion are zoonotic diseases, and brucellosis and scrapie are notifiable diseases (Kirby *et al.*, 2010).

NFSCo works with around 100 fallen stock collectors around the country (www.nfsco.co.uk/). Based on mortality statistics and the numbers of livestock in the UK, NFSCo believes that there is widespread non-compliance with the regulations (www.nfsco.co.uk/pdf.../2009_Dec_NFSCo_member_newsletter13122011103720.pdf; Gwyther *et al.*, 2011). Michael Seals, chairman of NFSCo, concluded that *more than a few* farmers are flouting the law to avoid the cost of paying NFSCo to collect and dispose of the corpses (http://www.dailypost.co.uk/news/local-news/prosecution-threat-over-stock-disposal-2731843). To try to address this problem, in 2011 Michael Seals called, unsuccessfully, for the more stringent compliance and inspection regulations introduced by the Welsh Assembly in 2010 to be enforced uniformly across the UK (Anon., 2011).

Number of fallen stock collected by hunts in the past

During the 1990s, one report stated that 200 hunts collected about 866,000 fallen stock each year. The Exmoor Foxhounds, for instance, collected fallen stock from some 250 farms and the Bedale Foxhounds collected deadstock and casualty animals from at least 400 farmers. The amount of raw flesh needed by each hunt depended on the number of hounds: each year the Duke of Buccleuch's Hunt collected 3500 head of stock to support 40 couple of hounds, and the Gelligaer Farmers' Foxhounds handled about 20 cows a month and 15 sheep a week to feed 35 couple of Welsh foxhounds. In fact, hunts collected more carcases than they needed as a service to farmers: the Cottesmore Hunt, for example, collected about 60% more flesh than they required to feed their hounds. Despite the financial burden, the benefit of having flesh to feed their hounds was such that hunts without incinerators paid to have the waste taken away for disposal (Foxford, 1997).

Another report estimated that hunts were handling an estimated 415,000 carcases, and the average hunt kennel might dispose of 100 to 200 tonnes of waste (bones, offal, etc.) per annum, with larger hunts disposing of 400 tonnes or more per annum (Cobham Resource Consultants, 1997). These wastes were collected by renderers or incinerated at the kennels. Of the 264 hunt kennels registered by MAFF in 1999 as collectors and processors of fallen stock, 150 had their own incinerators (Hunt, 2000).

In their submission to the Burns Inquiry, the Masters of Foxhounds Association (MFHA) said that 89% (179/196) of the recognised packs of fox and deer hounds were collecting fallen stock (http://webarchive.national-archives.gov.uk/20080727002638/http://www.hunting-inquiry.gov.uk/mainsections/report.pdf). A survey by the Countryside Alliance found that, of the 318 packs of bassets, beagles, fell hounds, foxhounds, harriers, staghounds and minkhounds in England and Wales registered in 2000, 200 collected 366,000 fallen stock per annum i.e. an average of 1830 per hunt, and 80% of hunts estimated that the demand from farmers was rising, by up to 50% per annum. Of the 318 registered hunts, 152 owned their own slaughter house and 145 their own incinerator. The 200 hunts spent £3.37 million annually on collecting fallen stock, so average collection expenditure was £18,000 per hunt and £9.20 per animal (https://web.archive.org/web/20041210021916/http://www.countryside-alliance.org:80/cfh/010517hfof.htm).

In 2004 the Countryside Alliance said that the 143 UK hunt kennels offering a fallen stock service processed almost 500,000 carcases the previous year, and that many hunts had recently upgraded their premises and vehicles to ensure they meet the new higher biosecurity standards necessary to be a part of a new national scheme (http://www.thejournal.co.uk/news/north-east-news/hunts-fill-defra-fallen-stock-4648997).

Thus, during the latter part of the last century and first part of this, there were a diversity of figures both on the number of hunts collecting fallen stock, and the number of fallen stock collected each year. The range of estimates given over a period of around a decade is substantial, with the highest figure 2.4 times larger than the lowest. It is unclear whether, or why, the number of fallen stock collected by hunts should have varied so much over this period. However, it is clear that hunts were collecting a substantial number of fallen stock each year to feed their hounds.

Number of fallen stock currently collected by hunts

The number of hunts currently collecting fallen stock is equally unclear. The European Commission requires that approved animal by-product plants (these include any hunts collecting fallen stock) are listed in thirteen sections (Table 4). The list of approved premises issued by Defra on 22nd September 2017 includes the majority of hunts operating in Great Britain: basset hounds, beagles, bloodhounds, buckhounds, draghounds, foxhounds, gun packs, harriers, minkhounds and staghounds are all on the list.

Table 4. Number of hunts on Defra's list of approved animal by-product plants in Great Britain issued on 22nd September 2017

Section	Purpose	No. of hunts
I	Establishments or plants carrying out intermediate activities and plants storing animal by-products	2
III	Incineration/co-incineration/ combustion plants	6
X	Specified users	252
XI	Collection centres	143
XIII	Other specified operators	7

Of the 252 hunts listed as specified users by Defra on 22nd September 2017 (https://www.gov.uk/government/publications/animal-by-product-operating-plants-approved-premises), 27 were listed as users of category 1 ABPs. Of these three were listed as only using category 1 ABPs; the other 24 were listed as using other categories as well. Most hunts (175) were listed as using category 2 ABPs and 105 were listed as using category 3 ABPs; of these 53 were only using category 3 ABPs.

However, this list is not exhaustive because some packs of hounds operated fallen stock services as separate companies. For instance, the Dulverton East Foxhounds were not on Defra's 22nd September 2017 list of approved animal by-product plants (https://www.gov.uk/government/publications/animal-by-product-operating-plants-approved-premises), but the Dulverton Farmers Fallen Stock Company Ltd operated from the same address. Similarly, the Taunton Vale Foxhounds were not included on Defra's list but the Taunton Vale Casualty Service was listed, with the same postcode as the Taunton Vale Foxhounds kennels. A number of other packs shared kennels but only one pack was included on Defra's list of approved animal by-product plants (Table 5), although it would seem likely that both packs had the same feeding programme for their hounds and shared fallen stock. Other packs included on Defra's list of approved animal by-product plants, such as the Shropshire Beagles and Mink Hounds (presumably the Border Counties Minkhounds), suggest that the two hunts were operating a joint fallen stock collection service. Thus the figures used in this report on the number of packs feeding raw flesh to their hounds should be viewed as minima, although it is clear that the vast majority of packs of hounds in the UK are still fed, at least in part, on fallen stock (http://www.shootinguk.co.uk/gundogs/health/ask-the-vet/dry-food-best-gundog-nutrition-37175).

While the data suggest that the number of hunts that rely on fallen stock to feed their hounds has not changed significantly over the last few decades, there is no current information on the actual number of fallen stock being processed by hunts. The Avon Vale Hunt, for instance, takes the vast majority of fallen stock within their hunt country (http://avonvalehunt.co.uk/avh-kennels/), and the Old Surrey Burstow & West Kent Hunt collects 3500 carcases a year, mostly calves or bullocks and horses (http://www.osbwk.co.uk/the%20Hounds.htm). For hunt staff, this continues to take up a significant part of their day (http://avonvalehunt.co.uk/avh-kennels/; http://www.wilton-hunt.co.uk/about-us/our-hounds/).

Table 5. Examples of packs of hounds believed to share kennels but where only one pack was included on Defra's list of approved animal by-product plants issued on 22nd September 2017 (**https://www.gov.uk/government/publications/animal-by-product-operating-plants-approved-premises**)

Hunt not included on Defra's list	Hunt included on Defra's list
Cheriton Hunt (minkhounds)	Dulverton Farmers Hunt (foxhounds)
Courtenay Tracy Hounds (minkhounds)	South and West Wilts Hunt (foxhounds)
Eastern Counties Minkhounds	Stour Valley Beagles
East Lincs Basset Hounds	South Wold Hunt (foxhounds)
Exe Valley Buckhounds	Taunton Vale Harriers
Four Shires Basset Hounds	Old Berkeley Beagles
Hunsley Beacon Beagles	Holderness Hunt (foxhounds)
Leadon Vale Basset Hounds Three Counties Mink Hounds	Croome and West Warwickshire Foxhounds
North Bucks Beagles	Oakley Hunt (foxhounds)
North Warwickshire Beagles	Atherstone Hunt (foxhounds)
Per Ardua Beagles	South Notts Hunt (foxhounds)
Severn Vale Beagles	Berkeley Hunt (foxhounds)
Taunton Vale Foxhounds	Ilminster Beagles
Wyre Forest Beagles	North Herefordshire Hunt (foxhounds)

Since most hunts appear to be operating much as before the Hunting Act 2004 came into effect, it seems reasonable to assume that the number of fallen stock required by hunts is still in the hundreds of thousands and is therefore a substantial proportion of all fallen stock. A survey of fallen stock undertaken by the State Veterinary Service in 1998 found that around 55% of calves, 35% of adult bovines, 25% of sheep and goats, and 10% of pigs and lambs were disposed of through hunt kennels (**https://publications.parliament.uk/pa/cm200001/cmhansrd/vo010227/debtext/10227-16.htm**). In 2003, when burying fallen stock was banned in EU member states, fallen stock comprised 1.3 million adult cattle, sheep, pigs and horses and more than 2.6 million immature animals, as well as poultry (**http://www.telegraph.co.uk/news/uknews/1424452/Farmers-may-leave-carcasses-to-rot-after-burial-ban.html**).

Transport of fallen stock

Owners can arrange for fallen stock to be collected or deliver it themselves to an approved site (**https://www.gov.uk/guidance/fallen-stock**; **http://www.gov.scot/Topics/farmingrural/Agriculture/animal-welfare/ABPs/fallenstock**). Collection is generally more expensive than delivering a carcase e.g. the Barlow (**http://www.barlow-hunt.org.uk/fallen_stock_collection**), the Curre & Llangibby (**http://www.curreandllangibbyhunt.co.uk/fallenstockservice.html**) and South Shropshire (**http://www.southshropshirehunt.com/kennels/fallen-stock/**) hunts. Other hunts, such as the Ludlow Hunt, do not collect fallen stock and rely on it being delivered to their kennel for processing and onward dispatch to the renderers for final disposal (**http://www.ludlowhunt.com/Farmers**).

Whether fallen stock is collected or delivered, Article 21 of EU Animal By-Products Regulation (1069/2009) sets out the requirements for collection and identification of ABPs. Detailed implementing rules are contained in Annex VIII of Regulation (EC) 142/2011. ABPs must be transported in sealed new packaging or covered leak-proof containers or vehicles. Containers must be dedicated to the use of specific categories of ABPs and, where they are not, they must be cleaned and disinfected after each use to prevent cross contamination. Article 22 of EU Animal By-Products Regulation (1069/2009) requires that records are kept of any carcases that are sent for disposal, and Article 21 requires that, during transportation, carcases are accompanied by a commercial document or, in certain circumstances, a health certificate. The commercial document must record: the date on which the material is taken from the premises; a description of the material; the quantity of the material, in weight or volume; the place of origin of the material; the name and address of the transporter; the name and address of the receiver and its approval or registration number if appropriate; and the approval or registration number of the plant of origin if appropriate (**www.defra.gov.uk/publications/.../pb13688-animal-by-products-controls-111130.pdf**; **https://www.daerani.gov.uk/articles/fallenstockguidance**).

NFSCo stresses that it is particularly important that biosecurity guidelines are followed because disease is not always apparent in fallen stock and so there is a real risk of collectors transferring diseases between farms. For this reason, collectors and scheme members are required to adhere to NFSCo's biosecurity guidance as well as any biosecurity procedures required by the local authorities (**http://www.nfsco.co.uk/biosecurity-guidance.php**); see Box 6. It is unclear what biosecurity guidance is given to hunt kennelmen and others who collect fallen stock for hunts, or to farmers who arrange to deliver fallen stock to hunt kennels.

Box 6. Some of the biosecurity guidance issued by the National Fallen Stock Company (NFSCo) to prevent disease being spread between farms when fallen

stock are being collected (**http://www.nfsco.co.uk/biosecurity-guidance.php**)

Farmers wishing to deliver their own fallen stock to a collection centre must:-

(a) make arrangements in advance, with the collector for the receipt of the fallen stock. It is at the collection centre's discretion whether to accept material in this way

(b) transport their own fallen stock only

(c) use a vehicle/trailer which is clean, fully enclosed (a flexible sheet roof is acceptable) and sealed to avoid any loss of fluids while in transit

(d) cleanse and disinfect their vehicle, particularly the load section used to carry the fallen stock, after every such delivery. The farmer should consider carrying out this cleansing before returning to the farm, to minimise any risk of introducing disease back onto the farm

Guidance for collectors includes the following:-

Vehicles must comply with the relevant provisions of the Animal By-Product Regulation(s) and any additional local byelaws when collecting and transporting carcases. Fallen stock must be transported in a vehicle that is lined with impervious easily cleaned material and, where appropriate, that is equipped with an adequate sized tank to collect all blood and liquids released from the carcass …. The vehicle and/or container(s) used must have, where applicable, a secure door and sealed cover. A flexible sheet roof is acceptable provided it is secure, impermeable, easy to clean, tight fitting and vermin proof and prevents the escape of liquids …. Before arrival at each and every farm, collectors must ensure that the outside of vehicles or trailers used to collect dead stock are cleansed and disinfected to the same standards required by the Transport of Animals (Cleansing and Disinfection) (England) Order 2003 and its equivalent in Scotland, Wales and Northern Ireland before the vehicle enters any premises. The inside and outside of the vehicle and fallen stock part of the vehicle or trailer must also be thoroughly cleansed and disinfected before the first pick up of the day …. Before collectors leave the premises they must cleanse and disinfect vehicles of all visible contamination with manure, slurry or similar material (including where appropriate, cleaning of the inside of vehicles, especially foot wells and pedals). If this is not possible, the outside of the vehicles and trailers must be cleansed and disinfected before they are taken onto another premises with farm animals. This may mean returning direct to the approved collection/disposal premises for a full clean-down before making another collection

It should go without saying that equipment contaminated with mucus, faeces and blood from fallen stock is likely to harbour infectious organisms (Caldow *et al.*, 1998; Brennan et al., 2008; Brennan & Christley, 2012), and that the movement of vehicles and personnel used to collect fallen stock between farms poses a significant risk of disease transmission. However, a number of studies have highlighted that dead stock collection is one of the areas where biosecurity measures are weakest. Despite all the biosecurity advice to the contrary, fallen stock collectors often park their vehicles in areas where stock have access (Brennan *et al.*, 2008; Brennan & Christley, 2012) and, of all the different farm visitors likely to park in animal areas, fallen stock collectors were least likely to disinfect themselves and their vehicles after visiting areas where stock had access. Thus fallen stock collectors pose a high risk of spreading disease (Brennan *et al.*, 2008; Brennan & Christley, 2012).

The instructions given to hunt staff and vehicles collecting fallen stock are unclear: in a volume celebrating British field sports, the advice given to people seeking a career in hunt service was simply to remember that the van [used to collect fallen stock] *will want washing out as well or it will harbour flies and then maggots* (Jones, 1989).

The majority of the packs of hounds in Britain collect and/or receive fallen stock to feed to their hounds as raw flesh, although the exact number of hunts involved, and the number of fallen stock collected, is unclear. Several hundred-thousand fallen stock are used to feed hounds each year, and these constitute a substantial proportion of all fallen stock. While there are strict rules governing the collection and transport of fallen stock, fallen stock collectors are the farm visitors least likely to follow basic biosecurity rules or disinfect themselves and their vehicles, and so pose a significant risk of spreading livestock diseases between farms

The risks of using fallen stock as animal feed

Causes of death of fallen stock

There is no national system for monitoring causes of death in fallen stock, even though this can be a valuable source of surveillance information on diseases in farm stock (Alba *et al.*, 2015; Oliver, 2017). In the absence of routine *post mortems*, the limited information available on causes of death of fallen stock comes from statutory surveillance schemes and voluntary collection, but these sources of data have limitations, both with regard to their reliability and how representative they are (SHAWG, 2017). There are a few short-term studies of causes of death for fallen stock. For instance, cause of death could be determined for 74 of 106 ewes from north-east England: eight had acute fascioliasis, seven *Pasteurella*-type bronchopneumonia, six Johne's disease, six ovine pulmonary adenocarcinoma, two chronic fascioliasis, two *Salmonella* and two parasitic gastroenteritis, among other diagnoses (Lovatt & Strugnell, 2013). Between March 2014 and March 2016 The Fallen Stock Project examined 2472 carcases from 1053 beef and sheep farms from northern England (Box 7). This project identified literally hundreds of causes of death for fallen stock, many of which can be

transmitted to animals and/or humans (http://www.beefandlamb.ahdb.org.uk/wp-content/uploads/2016/11/BRP-Fallen-stock-bulletin-Autumn-2016-111116.pdf).

Box 7. Some of the causes of death identified by The Fallen Stock Project in 2472 carcases from 1053 beef and sheep farms from northern England (SHAWG, 2017)

- Over one in five lambs submitted died from a parasitic infection when combining deaths due to coccidiosis, Nematodirus and other parasitic worms. Johne's disease (paratuberculosis) was found in 6.8%
- There were over a hundred different diagnoses from 416 calf carcases, with pneumonia accounting for over 30% of diagnoses
- Of 259 cattle between six and 24 months old, pneumonia accounted for 21% of all diagnoses, clostridial disease for 18% and lungworm for 3.9%
- The 206 suckler cows had over 80 different causes of death; Johne's disease was the biggest single cause

Other than these limited studies, the cause of death for most fallen stock is rarely identified, even though most hunts that collect fallen stock are feeding category 2 ABPs to their hounds. However, the regulations on collecting and treating animal by-products at collection centres state that category 2 ABPs must come from animals which did not die as a result of a disease that could infect animals or humans (https://www.gov.uk/guidance/collecting-and-treating-animal-by-products-at-collection-centres). It is impossible to know whether the animals fed to hounds as category 2 ABPs died as a result of a transmissible disease without a routine *post mortem* of all fallen stock.

So, contrary to the regulations, in the UK hounds are routinely fed raw carcases and offal from fallen stock that died of diseases that can infect both animals and humans.

Should hounds be fed on fallen stock?

The disease risks associated with feeding hounds on fallen stock have long been recognised. A quarter of a century ago, on 3rd March 1992, Alan Meale MP presented a Ten Minute Rule Bill to prohibit dogs being fed on raw meat and offal derived from fallen or casualty farm animals to control hydatidosis. When introducing his Bill, Alan Meale MP said that *dogs fed on raw meat and offal from fallen livestock are a major source of a disease that not only costs the farm and meat industries millions of pounds, but annually kills people and puts hundreds in hospital for surgery* (https://publications.parliament.uk/pa/cm199192/cmhansrd/1992-03-03/Debate-3.html).

Nearly 20 years ago the EU's Scientific Steering Committee (SSC) recommended that, *if the reasons an animal died or was sacrificed is unknown or has been shown to involve a hazardous, chemical or biological agent, the fallen stock or suspect condemned material should be disposed of in such a way that any processing into human or animal consumption products is avoided* (EU Scientific Steering Committee, 1999). While the SSC considered it highly desirable that member states had a monitoring system to ensure that only fallen stock and condemned material of proper quality are recycled in feed, they recognised that it is not practical to have a reliable systematic identification of the cause of death or a determination of the type and level of toxic or infectious substances present in fallen stock on an animal-by-animal basis, which would be required before feeding raw flesh from fallen stock to hounds.

The SSC was also concerned about the potential for post slaughter infection or contamination of low risk material as a consequence of handling, transport and/or storage. For these reasons they proposed that none of the material from dead animals that died of non-specifiable causes should be used as animal feed except after appropriate sourcing and processing. For processing, the SSC recommended that the most appropriate method for inactivating the infectivity of the most heat-resistant conventional infectious agents was a standard of at least 133°C/20'/3bars (a hyperbaric production process at a temperature of not less than 133°C over a period of not less than 20 minutes, at a pressure of not less than 3 bars, without air entrapped in the sterilising chamber), or a validated equivalent method. In the absence of information on the risk of transmission of conventional and non-conventional infectious agents by hounds and working dogs, the SSC said that the feed for hounds used for hunting should comply with the same safety standards as for farmed animals intended for human consumption (EU Scientific Steering Committee, 1999).

While *post mortems* of fallen stock are not routine, the limited data available suggest that diseases that can be transmitted to hounds and humans are frequent causes of death. Despite the health risks, and the requirement that category 2 ABPs must come from animals which did not die as a result of a disease that could infect animals or humans, hunts routinely feed their hounds with fallen stock that has died of a variety of diseases

There is a significant risk of diseases being passed between hounds and horses

The main diseases spread by dogs to livestock

There is a significant risk of transmission of infectious diseases between dogs that walk or work on farmland, and livestock. These diseases threaten livestock health, welfare and productivity (**www.faifarms.com/wp-content/uploads/2016/03/Dogs-livestock.pdf**). Some of the more important diseases spread by dogs to livestock are outlined below: other diseases are discussed on pages 44 and 45.

Companion animals

The main concern in urban areas is the role dogs play in human toxocariasis. Disease is caused by the migrating larval stages of *Toxocara canis* and, less frequently, *Toxocara cati* (Fisher, 2003). Humans are infected with *Toxocara canis* by the accidental ingestion of infective embryonated eggs present in contaminated soil, unwashed hands after stroking dogs or from raw vegetables. In humans, *Toxocara* larvae fail to mature to adult worms and clinical manifestations of human toxocariasis vary from asymptomatic infection to severe organ injury, depending on the parasite load, the sites of larval migration and the host's inflammatory response (Elsheikha, 2013).

Human toxocariasis is a potentially serious infection, although the exact number of incidences in humans is unclear. In the 1990s approximately 100 cases were diagnosed each year, with 50 having serious eye damage. Nearly all were children, and about half of the most serious cases of toxocariasis occurred in families who had never owned a dog or a cat (EnCams, 2003). A survey of dog owners found that 54% had neither bought nor used worming tablets on their pets (**www.hps.scot.nhs.uk/documents/ewr/pdf2017/1711.pdf**). However, worming a dog will not eradicate *Toxocara canis* unless they are wormed regularly (EnCams, 2003).

In rural areas the main concerns are neosporosis and sarcocystosis. Neosporosis is caused by *Neospora caninum*, a coccidian parasite first detected in dogs in the mid 1980s. In the early 1990s it was confirmed as a major cause of abortion or still-birth in dairy and beef cattle; infected cattle are 37 times more likely to abort than uninfected cattle (**www.knowledgescotland.org/briefings.php?id=288**). Sarcocystosis is caused by protozoan parasites of the genus *Sarcocystis*: there are a number of intermediate hosts including dogs, and it can cause neurological disease and death in sheep (**https://www.nfus.org.uk/news/news/nfus-poster-campaign-halves-dog-fouling-farmland**). While other parasites can be spread to livestock from the faeces of pet dogs, neosporosis and sarcocystis are of particular concern because there are no licensed vaccines or drugs for these diseases and because of their economic impact on farming (**www.hps.scot.nhs.uk/documents/ewr/pdf2017/1711.pdf**).

Naïve cows grazing on pasture contaminated with dog faeces are susceptible to infection with *Neospora*, and an abortion storm can follow when a farm is infected for the first time. Once a cattle herd is infected with neosporosis, it can persist within the herd due to the vertical transmission between cows and calves, but there is no lateral transmission between cattle in the herd. The disease is on the increase in the UK; 17% of dairy cattle were exposed to the parasite in England, 90% of dairy herds in south-west England showed evidence of previous infection, and bulk testing of around 500 British dairy herds in 2012 suggested levels of 51%. Financial modelling predicts that the cost of *Neospora* in an average 121 cow herd is around £3,000 per year due to increased abortion rates in infected cows, premature culling and reduced milk yields.

Neospora can be picked up by dogs eating contaminated livestock material, such as placentas from newly calved cows, or by being fed contaminated raw meat. A survey on bovine abortion samples across Scotland (n=611) found that nearly 20% were positive for *Neospora* (**www.knowledgescotland.org/briefings.php?id=288**). Oocysts are very stable in the environment and stay infective for six months or longer in temperate conditions. An effective biosecurity plan is essential in putting a stop to infection from dogs: this includes controlling access of dogs to areas where cattle feed is kept, where cattle graze and where water run-off could wash dog faeces into drinking water (**www.hps.scot.nhs.uk/documents/ewr/pdf2017/1711.pdf**; **www.checs.co.uk/wp-content/uploads/.../MO2480_NeosporaReport_v6_3001.pdf**; **www.faifarms.com/wp-content/uploads/2016/03/Dogs-livestock.pdf**; **http://www.outdooraccess-scotland.com/sites/default/files//docs/risk_of_the_spread_of_disease_in_livestock_from_dog_faeces_-_briefing_note_for_access_authorities_0.pdf**).

Sarcocystosis is generally regarded as less of a problem than neosporosis, but can cause significant losses for sheep farmers because sarcocysts on a carcase can result in it being condemned. Dogs pick up the parasite by eating contaminated carcases or by being fed contaminated raw sheep meat. Faeces from infected dogs can contaminate pasture and potentially animal feed, water or bedding. As with neosporosis, the best way to address the problem is to introduce management practices that minimise the risk of infection. These include prompt removal of carcases, placentas and still-births to limit the spread of disease by dogs and foxes and not feeding dogs on raw meat (**http://www.outdooraccess-scotland.com/sites/default/files//docs/risk_of_the_spread_of_disease_in_livestock_from_dog_faeces_-_briefing_note_for_access_authorities_0.pdf**).

Hounds and hunting dogs

Other than occasional case studies, there is little detailed information on the diseases of working hounds because many breeders believe that veterinary care, including routine veterinary treatment, reduces their ability to select the healthiest hounds. Also, sick hounds

Otterhounds pose a particular risk of spreading pathogens to water sources

Packs of hounds pose a particular risk to livestock farmers because of the large number of free-running dogs

are often culled because of the potential veterinary costs of treatment, especially with large numbers of animals (von Recum, 2002). There is also considerable reticence among hunt staff to admit to any health problems among their animals (Palmer *et al*., 1984), so hounds no longer able to hunt are generally culled without establishing their underlying health issues.

The Countryside Alliance estimated that the packs of foxhounds registered with the MFHA put down about 3000 hounds a year (Burns *et al*., 2000); this figure did not include hounds in other types of packs or unregistered hunts. So a reasonable estimate might be that over 4000 working hounds were being culled each year because they were no longer able to hunt with the rest of the pack. According to one ex-huntsman, with a pack of 60 foxhounds, eight to ten (13-17%) are disposed of every season, generally when they are older than five or six years and past their prime (**www.greanvillepost.com/2014/07/10/the-sordid-truth-about-fox-hunting/**). In their evidence to the Burns Inquiry, the Countryside Alliance said that it is *a common, but not universal, practice for hounds belonging to the registered packs to be put down after some six or seven years' hunting, when they are considered to have reached the end of their working lives*. Hounds typically start hunting when around 18 months old, so these hounds will have been culled when 7.5 to 8.5 years old. The average age of 52 foxhounds culled in Ireland was 6.5 years, with a range of 1.5 to 12 years (Jahns *et al*., 2011). So it would appear that most foxhounds are culled when around half to two-thirds of their life expectancy of around 11 years (Fogle, 2000).

Despite the large number of hounds being euthanized each year, the only detailed analysis of the health of hunting hounds in Britain and Ireland is a study of 52 culled hounds (42 foxhounds, 10 beagles) from ten Irish hunting kennels. No reason was given for culling 15 of the hounds, 10 were culled for behavioural changes, 10 for being too slow, 6 for being too old, 4 for chronic skin disease, 4 for clinical disease and 3 for lameness (Jahns *et al*., 2011).

Nine (17%) of the 52 randomly-selected hounds included in the Irish study had debilitating, progressive, potentially fatal diseases, including one case of bovine tuberculosis (bTB). Worryingly, most of these animals were culled for other reasons and the case of bTB would not have been detected if that particular hound had not been included in the study (Jahns *et al*., 2011). This strongly suggests that large numbers of other cases of diseases in working hounds go undetected, because the hounds are simply culled and disposed of when they are no longer able to hunt with the rest of the pack.

The report of bTB in one of the 52 hounds examined *post mortem* is particularly interesting since bTB is a rare disease in dogs, although there have been occasional reports in working terriers involved in fights with badgers (van der Burgt *et al*., 2009). Before they identified bTB in the culled foxhound, the Department of Veterinary Pathology University College Dublin in Ireland had only diagnosed the disease in dogs twice in the previous decade, despite the relatively high prevalence of infection in Irish cattle and spill over into some wildlife species (**www.agriculture.gov.ie/animalhealthwelfare/diseasecontrol/bovinetbbrucellosiseradicationschemes/**; Jahns *et al*., 2011).

In the UK, bTB is rarely recorded in dogs (**https://www.daera-ni.gov.uk/articles/bovine-tuberculosis-tb-pets**). Only eight cases were diagnosed in dogs from 1993 to 2009 (van der Burgt et al., 2009), and these were invariably isolated cases (Greene & Gunn-Moore, 1998; Bauer *et al*., 2004). Thus the number of hounds infected with bTB at the Kimblewick Hunt is particular remarkable (Table 6). From December 2016, 25 foxhounds were identified as being infected with bTB and destroyed; while the number of hounds involved has still to be confirmed (Anon, 2017c), anecdotal reports suggest that the number culled was even higher (e.g. **http://www.huffingtonpost.co.uk/entry/hounds-kimblewick-hunt-killed-after-bovine-tb-outbreak_uk_58bfe512e4b0d1078ca25a6b**). On 28th February 2017 the MFHA said that there would be an update on the situation when more information became available (**http://www.mfha.org.uk/news/37-hunting-news/182-hound-health**); a year after the event no further details have been released.

It remains unclear how so many hounds became infected with bTB, or for how long the disease had remained undetected in the pack. The case in Ireland, where the

The Kimblewick Hunt on 25th February 2017 after at least 25 hounds had been destroyed because they had bTB. The sign in the yard says *Biosecurity Measure – ALL farmers please spray wheels* and *Biosecurity Measure – Please dip your feet in and out of Kennels*. This is a long way short of basic biosecurity advice

disease was only detected by chance at *post mortem* (Jahns *et al.*, 2011), suggests that this could have been for some time. Following confirmation of bTB in the Kimblewick hounds, there was no further contact between the Hunt's hounds and other packs, but apparently there had been contact with other hunts prior to this, when the Kimblewick hounds were likely to have been infected with bTB, and may have been infectious. A monitoring and testing protocol was implemented across the country (Anon., 2017c), presumably to look for spread of bTB to other packs of hounds, since inhaling aerosols from infected animals is a common route of infection (**https://www.gov.uk/government/publications/bovine-tuberculosis-tb-in-domestic-pets**). The results of this monitoring programme are yet to be announced.

While it is most likely that the original source of infection for the Kimblewick Hunt's foxhounds was an infected carcase, it is unclear whether all the hounds were infected by eating contaminated meat and/or offal, or whether some hounds were infected by lateral transmission in the kennels. Ingestion of infected meat and breathing in aerosols from close contact with infected animals are both potential routes of infection (**https://www.gov.uk/government/publications/bovine-tuberculosis-tb-in-domestic-pets**). Hunts house large numbers of hounds together (over 100 in the larger hunts), and so high levels of kennel hygiene are required to prevent disease transfer within packs of hounds.

After the cases of bTB in the Kimblewick Hunt's hounds were made public, LACS sent trained investigators to the kennels. They reported that, *For a property that was the centre of a bTB outbreak, biosecurity measures seemed lapse to say the least. A couple of biohazard signs stood in the yard, where animal carcasses lay freely, with dogs wandering around them. There was no cordon, and no vehicle disinfectant measures to be seen, in spite of a vehicle being witnessed arriving back at the property* (**https://www.league.org.uk/blog/defrasresponsetohuntbtboutbreakwillbetelling**).

Assuming that the Irish study (Jahns *et al.*, 2011) is representative, 13-17% of the hounds culled in Britain each year will be infected with debilitating, progressive, potentially fatal diseases that could be transferred to other members of the pack, livestock and/or people. So with around 4000 working hounds being culled in Britain each year, between 520 and 680 of these hounds will have been infected with a variety of diseases. However, these went undiagnosed because the hounds were culled for reasons such as being too slow, which in itself may well reflect some underlying disease or other ill-health problem. The limited data available suggests that ill-health has always been an underlying factor that determines whether a hound is culled: the 125 hounds examined *post mortem* as part of a study into equine hydatidosis were *put down because of old age, sickness, or wilfulness;* what constituted *sickness* was not reported (Thompson & Smyth, 1975).

Despite the paucity of quantified information, a wide range of diseases have been reported in hounds in Britain and Ireland, including notifiable diseases (Table 3) and potential zoonoses; some examples are listed in Table 6.

Table 6. Examples of parasites and diseases recorded in packs of hounds in Britain and Ireland

Parasite/disease	History	Source
Anthrax	The hounds of the Staintondale Hunt were being monitored after being fed half the carcase of a cow that had died of anthrax: the kennels were under Police supervision	*Hull Daily Mail*, 9 March 1936
	An outbreak of anthrax in a pack of hounds at Kennet, Suffolk was attributed to feeding them raw meat from a Jersey cow that had died of anthrax	Davies *et al.* (1957)
Aujeszky's disease (pseudorabies)	Of a pack of 51 harriers in south-west England, 11 died of Aujeszky's disease after eating pig carcases	Gore *et al.* (1977)
	In 1983, 24 of 72 foxhounds in a pack near Lincoln died of Aujesky's disease, or were euthanized when the symptoms became too severe, after being fed pig meat	Murdoch (1990)
	Two foxhounds in a pack of 27 in the Irish Republic died of Aujeszky's disease five days after eating uncooked pigs' offal	Fagan (1990)
Botulism	An outbreak of acute paralysis in a pack of foxhounds was almost certainly due to botulism type C originating from raw and partially cooked meat	Darke *et al.* (1976)
Bovine spongiform encephalopathy	Before the BSE regulations came into effect (page 22), there were several cases of packs with hounds suffering from what was described at the time as ataxia (an impaired ability to coordinate movement, often characterized by a staggering gait and postural imbalance); these cases were associated with eating cattle paunches	
	There is historical evidence to suggest that the condition occurred in one kennel of foxhounds in the early 1930s	Palmer *et al.* (1984)
	The problem was recognised in seven harriers and two beagles in the late 1970s; the condition became so severe that up to 75 per cent of animals were lost before 7 years of age	Palmer & Medd (1981)
	Ataxia was described in seven foxhounds (from three hunts), seven harriers from one hunt, and two beagles from one hunt, all in England, aged from 2 to 7 years. The beagles were kennelled with foxhounds and otterhounds. Of 36 hounds in that pack, 60% were eventually affected	Palmer *et al.* (1984)
	A similar condition was diagnosed in 12 foxhounds (from two packs) and two harriers from one pack, age range 3 to 6 years. No further cases were observed when the hounds were fed raw meat rather than ruminant stomachs	Sheahan *et al.* (1991)
	In 1991 scientists at the Central Veterinary Laboratory and the Veterinary Investigation Service examined the brains of 444 hunting hounds to investigate the cause of ataxia. Scrapie associated fibrils were found in some of the hounds, which were lagging behind the rest of the pack and not doing very well. The hounds were assumed to have picked up the infective agent before September 1990 when the SBOs thought to carry BSE were banned; no further work was undertaken to confirm the link with BSE	http://www.independent.co.uk/news/dogs-face-risk-from-mad-cow-disease-1269772.html; http://www.heraldscotland.com/news/12328245.Signs_of_BSE_in_dogs__apos_kept_secret_apos_/
Bovine tuberculosis	Of 52 culled hounds in Ireland (42 foxhounds, 10 beagles), one had bovine tuberculosis, contracted from being fed carcase material from an infected cow or from infected materials when out hunting	Jahns *et al.* (2011)
	In 2016 and 2017 25 hounds belonging to the Kimblewick Hunt were euthanized following infection with bTB, thought to have been contracted by eating a contaminated bovine carcase	*Bucks Herald,* 9 March 2017
Cystic echinococcosis	A man employed as a kennelman with three packs of foxhound in Gloucestershire and Wiltshire from 1980-2001 had a 7.5 cm hydatid cyst surgically removed from his liver; he regularly fed the hounds with raw meat, liver and lungs from sheep, cattle and horses (normally fallen stock)	Craig *et al.* (2012)

Parasite/disease	History	Source
Distemper	Distemper was first described in 1809 by Edward Jenner in the Earl of Berkeley's foxhounds Distemper was such a widespread problem for packs of hounds that a publicly-funded campaign in Britain between 1922 and 1933 successfully developed a canine distemper vaccine. It was coordinated by *The Field* Distemper Fund and spearheaded by landed patricians, whose key aim was to preserve foxhunting	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2128789/; Bresalier & Worboys (2014)
Equine hydatidosis	High level of hydatid infection in hunters, as opposed to thoroughbred horses of similar age, was attributed to hunters grazing pastures frequented by infected foxhounds, whereas thoroughbreds usually grazed pastures where dogs were excluded	Cranley (1984)
Equine influenza A virus H3N8	In September 2002 an outbreak of severe respiratory disease in a pack of 92 foxhounds was caused by equine influenza A virus; one died and six were euthanized. A retrospective analysis suggested that this was not the only incident of equine influenza to have infected foxhounds in the UK. While the infected hounds could have been infected by aerosols from nearby horses, the week before they had been fed the carcases of two recently euthanized horses and may have inhaled virus while consuming raw lung material. In another case the foxhounds may have been infected with equine influenza while being transported in the same vehicle as horses. Dogs kept in close contact with horses in Australia were also infected during an equine influenza outbreak	Daly *et al.* (2008, 2010) Newton *et al.* (2007); Kirkland *et al.* (2010)
Foot-and-mouth disease	Farmers called on the North and South Cheshire hounds to stop cub-hunting because there had been a dramatic increase in the number of FMD cases after the hunt started cub-hunting four days a week	*Derby Daily Telegraph,* 13 October 1883
Hydatid disease	A survey of 121 hunting dogs, mostly foxhounds, from 21 kennels found 28.8% were infected with *Echinococcus granulosus;* an alarming increase in hydatid disease in horses was believed to be due to the increased use of raw meat and offal to feed hounds after the Second World War	Thompson & Smyth (1974)
Neospora caninum	In the UK, foxhounds are routinely fed bovine carcases and have a higher prevalence of *Neospora caninum* antibodies than pet dogs, and infected foxhounds can excrete oocysts for extended periods	Hemphill et al. (2000); McGarry *et al.* (2003)
Rinderpest (cattle plague)	There was a major outbreak of rinderpest in Britain from 1865-1867, and tenants and landowners in the area hunted by the Duke of Grafton's Hounds met at Towcester to discuss whether the hunt should continue to operate on their land in view of the potential risk of spreading the disease. Rinderpest was last recorded in Britain in 1877 and the virus was declared eradicated worldwide in 2011, although it remains a notifiable disease in the UK	https://www.gov.uk/guidance/rinderpest; *Northampton Mercury,* 3 February 1866
Salmonella montevideo	*Salmonella montevideo* causes abortion in sheep. 50 of 61 foxhounds in Scotland were infected (and two aborted) after three hounds had been lost during a day's hunting and fed on dead ewes and aborted foetuses on a farm with an infected ewe flock before being found by the huntsman	Caldow & Graham (1998)
Sarcoptic mange	The North East Cheshire Drag Hunt's entire pack of 29 foxhounds were so badly infected with mange (presumably sarcoptic mange) that they were due for destruction Five culled hounds with chronic dermatitis were from a kennel that had suffered problems with sarcoptic mange in the previous years	*Daily Mirror,* 4 May 1971 Jahns *et al.* (2011)

Despite the absence of quantified studies into the diseases of hounds in Britain, these case studies highlight a number of consistent themes: infections, including notifiable diseases and zoonoses, are transmitted from livestock to hounds by eating raw meat; diseases are transmitted between hounds in kennels because of the large number of animals housed together; diseases are passed from horses to hounds housed and/or transported in close proximity; diseases passed from foxhounds to kennel workers can remain undetected for extended periods; and hounds contaminating pasture with faeces poses a disease risk to livestock.

In addition to posing a significant risk to livestock, there are also risks to hounds from repeatedly using the same fields or paddocks. Six or seven couple of foxhounds in one British hunt had severely inflamed feet because their grass yard was contaminated with faeces and eggs from the hookworm *Uncinaria stenocephala*. The larvae had burrowed into the feet of the hounds, causing severe inflammation and secondary infections (Barker, 2010b). The MFHA of America highlights the risk of disease accumulation on fields heavily used by packs of hounds and warns that, if they are used, they must be regularly cleansed of faeces (Foster & Wood, 2015).

Many of the risk factors associated with the spread of disease have long been recognised. In the *Livre de chasse*, written between 1387 and 1389, Gaston Phébus warned against feeding hounds from the carcase of a wild boar. This book became the standard textbook on mediaeval hunting techniques. More recently, several pieces of British legislation have recognised the role of hunting with hounds in spreading disease. The Cattle Plague Order 1928 as amended and the Rabies (Control) Order 1974 conferred wide-ranging powers to deal with any outbreak of rinderpest and rabies respectively, including banning hunting with hounds. From 23rd February to 17th December 2001, the Foot-and-Mouth Disease Declaratory (Controlled Area) Order 2001 banned all hunting with hounds in Britain because of the risks that hounds would spread FMD to new areas of Britain. From 17th December 2001, some packs of hounds were licensed to hunt in FMD-free areas, and from 11th February 2002 any hunt could be licensed so long as certain restrictions were observed (Baker *et al.*, 2002).

Keeping large numbers of hounds together facilitates disease spread

The role of hounds in spreading equine hydatidosis

The best quantified information on the role that packs of British hounds play in the spread of disease is for hydatidosis. Equine hydatidosis (caused by *Echinococcus equinus*) and ovine hydatidosis (caused by *Echinococcus granulosus*) are endemic in the UK, maintained respectively in horse/foxhound and sheep/dog transmission cycles (Thompson & Smyth, 1974).

Before the Second World War, equine echinococcosis was rare in Great Britain (Southwell, 1927). In the 1940s, the disease was still uncommon and localised (Thompson & Smyth, 1974). However, by the 1960s 45% of 349 horses from across England and Wales were infected (Cook, 1965). In the early 1970s, 61.7% of 2133 slaughtered horses were infected (Dixon *et al.*, 1973), and prevalence rates at several slaughterhouses ranged from 35 to 60% (Thompson & Smyth, 1975).

To determine the role of packs of hounds in spreading the disease, 125 hounds (120 foxhounds, four basset hounds and one beagle) from 21 hunts were examined *post mortem* for *Echinococcus equinus*; 36 (28.8%) were infected. Of the 21 hunts, 11 (52.4%) harboured infected hounds. The rise in horse hydatidosis was believed to be due to an increase in feeding raw meat and offal, including horse offal, to hunting dogs following the Second World War, and there was a clear link between infection and feeding raw meat. Of the 21 hunts, all 11 infected hunts fed raw horse offal to their hounds (Thompson & Smyth, 1975). While the Meat (Sterilization) Regulations 1969 prevented hunt kennels from getting raw meat from a knacker's yard, they were still able to obtain fallen stock or casualty animals directly from farmers. The continued widespread distribution of hydatid tapeworms in foxhounds through the 1970s was conclusive evidence of loopholes in the Meat (Sterilization) Regulations 1969 (Williams, 1982).

Other risk factors identified as contributing to the rapid increase in the prevalence and distribution of equine hydatidosis were: the widespread distribution of hunts, and the large number of hounds, which enabled them to spread infective ova on grazing land over wide areas; hunt's horses were normally exercised in the same field or paddock as the hounds; and housing hounds and horses in close proximity (Thompson & Smyth, 1974, 1975).

Thompson (2008) suggested that a decline in horse infection may follow the introduction of the Hunting Act (2004) because this may reduce the widespread contamination of grazing land by infected hounds. However, while the Hunting Act 2004 changed hunting practices, changes in the number of hunts or the areas they covered were relatively minor. A study in 2010 and 2011 found that 25.5% of the foxhound faecal samples from eight packs of foxhounds (three in England, five in Wales) were coproantigen ELISA positive (25.5%),

with coproantigen prevalence of *Echinococcus* infection particularly high in hunts that fed their hounds on raw meat e.g. 22/71 (30.9%) and 30/49 (61.2%) faecal samples in two Welsh packs and 28/63 (44.4%) and 10/57 (17.5%) faecal samples from two English packs. The study concluded that foxhounds still played a significant role in the transmission of *Echinococcus equinus* (Lett, 2013).

The role of hounds in spreading ovine hydatidosis and other tapeworms

Ovine hydatidosis is more localised than equine hydatidosis, being primarily restricted to Wales and the bordering areas, and the Hebridean Islands in Scotland (Boufana *et al.*, 2015). While it represents a significant public health risk, its control is not well addressed by national and international authorities (Lembo *et al.*, 2013).

In the 1970s, tapeworms were found in 381 (69%) of 552 foxhounds in 12 packs in Dyfed. Two packs (72 hounds) were cestode free. Of the dog/sheep species of tapeworm, the most common was *Taenia hydatigena*, found in 270 (49%) foxhounds in ten packs. *Echinococcus granulosus* was found in 162 (29%) foxhounds in eight packs, *Taenia multiceps* in 41 (7.5%) hounds in four packs, and *Taenia ovis* in 32 (6%) hounds in six packs. Of the dog/rodent species, *Taenia pisiformis* was found in 53 (10%) hounds in three packs, and *Taenia serialis* in six (1%) hounds in two packs. *Dipylidium caninum* was found in 24 (5%) hounds in two packs. Although *Dipylidium caninum* is usually the most common tapeworm in dogs, the low incidence in these foxhounds may have been due to the practice of bathing hounds frequently to control mange. This would also have reduced the numbers of dog fleas, *Ctenocephalides canis*, the intermediate host of this cestode (Williams, 1976a).

This study also highlighted the relationship between cestode infection and diet in foxhounds. The two packs free of cestodes were not fed sheep meat or offal, nor were they fed raw offal from cattle and horses. On those rare occasions when offal from cattle and horses had to be fed, it was boiled first. The other packs were fed a variety of meat and offal when available, and for three of these packs sheep carcases were the major source of protein. In a pack fed the carcases, including the heads, of 20 sheep showing signs of 'gid' (caused by the larval stage of *Taenia multiceps*) during the previous three to four months, 20% of the hounds were infected with adult *Taenia multiceps*. Regular anthelmintic treatment at three-monthly intervals was practised in the two cestode-free packs, whereas treatment of the hounds in the other packs was irregular, and they were usually only treated when tapeworm segments were observed in their faeces.

In the 1980s foxhounds continued to show high prevalence levels for *Echinococcus granulosus* and other tapeworms that posed disease risks to livestock. Cestodes were found in 129 of 875 foxhounds (14.7%) from 20 packs in Powys, mid-Wales, sampled from 1983-1988: *Taenia hydatigena* was found in 57 hounds (6.5%), *Echinococcus granulosus* in 27 (3.1%), *Dipylidium caninum* in 25 (2.9%), *Taenia ovis* in 14 (1.6%), *Taenia pisiformis* in 10 (1.1%), *Taenia serialis* in five (0.6%) and *Taenia multiceps* in four (0.5%) (Jones & Walters, 1992a). Slightly higher prevalence rates were found in dogs from 315 farms in the area: 161 out of 882 (18.3%) had cestodes (Jones & Walters, 1992b), whereas the lowest prevalence rates were in wild foxes: 22 out of 197 (11.2%) had cestodes (Jones & Walters, 1992a).

Another study of foxhounds and gundogs in Clwyd, Wales found that 47 of 162 foxhounds (29%) and six of 25 gundogs (24%) were infested with cestodes. Various species of *Taenia* were found in both groups of dogs, with *Taenia hydatigena* being most common. *Echinococcus granulosus* and *Dipylidium caninum* were only found in the foxhounds. There was a close relationship between diet, worming procedures and cestode infestation, again highlighting the particularly important role foxhounds play in the life-cycle of cestodes because their diet frequently includes uncooked carcases and because they hunt over large areas of countryside, facilitating the widespread dissemination of infective eggs (Stallbaumer, 1987).

A review of 100 published studies from a wide range of countries highlighted that the epidemiological factors associated with an increased risk of *Echinococcus granulosus* infection in dogs included feeding with raw viscera, the possibility of scavenging dead animals, a lack of anthelmintic treatment and the owners' poor health education (Otero-Abad & Torgerson, 2013).

Diseases in hounds elsewhere in the world

A similar situation is seen in hunting hounds elsewhere in the world (Table 7). As the data show, a number of factors identified in packs of hounds in the UK mean that hounds and other hunting dogs also pose a heightened risk of harbouring, transmitting and spreading infectious diseases and zoonoses elsewhere in the world. Common risk factors include: feeding hounds on raw meat, and particularly offal; interactions between packs of hounds at field trials and shows; lending hounds to other packs for breeding or moving hounds between packs; direct contact between hounds and infected wild animals, especially when the hounds *break up* the carcase of an animal they killed; direct contact between hounds, horses and other livestock; poor veterinary care, especially inadequate treatment protocols to control disease levels; failing to monitor disease in packs of hounds routinely; failing to maintain high standards of kennel hygiene; housing large numbers of hunting dogs together; and hunting in dense vegetation where the hounds are particularly likely to pick up ticks, which are vectors for a number of diseases.

Table 7. Examples of parasites and diseases recorded in hounds and other hunting dogs in other parts of the world

Parasite/disease	History	Source
African horse sickness Africa	African horse sickness is a highly infectious disease of horses, mules, donkeys and zebras caused by orbiviruses spread by midges, mosquitos and ticks. The hounds of the Gwelo Hunt Club in Zimbabwe were fed the carcases of mules that died following inoculation for horse sickness. Five hounds died of horse sickness, two recovered, and 16 were unaffected In 1955 seven of a pack of about 50 hounds belonging to a hunt club in South Africa near Johannesburg died of horse sickness or were euthanized after being fed meat from three horses: it was usually cooked but raw meat was fed after exercise	Bevan (1911) Haig *et al.* (1956)
Alveolar echinococcosis in Europe	Prevalence rates of *Echinococcus multilocularis* were <0.5% in privately owned dogs in Denmark, France, Germany and Switzerland, but 3 to 8% in dogs with predatory habits and those able to roam more widely Of 289 dogs examined in Slovakia, *Echinococcus multilocularis* was recorded in sheep dogs, guard dogs and hunting dogs: the most important risk factors were catching rodents and eating raw viscera. It was previously unrecorded in Slovakia: hunting and similar dogs were playing a major role in disease transmission	Deplazes *et al.* (2011) Antolová *et al.* (2009)
Aujeszky's disease (pseudorabies) in Europe	Aujeszky's disease is present in wild boar in much of Europe. Highest seroprevalences are in Mediterranean countries (Croatia, Italy and Spain), followed by central and eastern Europe (Austria, Czech Republic, Germany and Slovenia). Seroprevalences are generally lower in central and northern Europe (parts of France and Germany, the Netherlands, Sweden and Switzerland) but moderate to high in Belgium, Luxembourg and western Germany Hunting dogs in Poland have been infected by eating raw meat and offal from wild boar, and from bites when hunting badgers	Cay & Letellier (2009); Meier *et al.* (2015) Szczotka-Bochniarz *et al.* (2016)
Aujeszky's disease (pseudorabies) in the US	In the US hunting dogs become infected after eating raw meat from feral pigs or by direct contact during hunts. It is almost always fatal in dogs, with most deaths within 48 to 72 hours. For instance, in Arkansas 10 hunting dogs died after catching, and eating meat from, a feral pig While pseudorabies is not transferrable to humans, the Arkansas Department of Health stressed that feral pigs carry multiple viruses, bacteria and parasites that pose health risks to both humans and dogs. Most notable is swine brucellosis. Others include: anthrax, *Escherichia coli*, hepatitis E virus, swine influenza virus, leptospirosis, rabies, salmonellosis, trichinosis, tuberculosis and tularemia	http://www.gon.com/news/kill-feral-hogs-but-handle-them-carefully-for-your-health-and-your-dogs; www.cfsph.iastate.edu/Factsheets/pdfs/aujeszkys_disease.pdf; http://www.arkansasmatters.com/news/pseudorabies-outbreak-kills-hunting-dogs-in-sevier-county/205327105; Cramer *et al. (2011)*
Botulism in the US	Lower motor neuron dysfunction due to type C botulism developed in 19 America foxhounds while they were out hunting: 10 became weak and 9 became quadriplegic, three of which died	Barsanti *et al.* (1978)
Canine leprosy (canine leproid granuloma syndrome - CLGS) in Australia, New Zealand and the US	CLGS was first described from Zimbabwe in 1973, and is caused by fastidious mycobacterial species that are probably transmitted by biting insects. Several cases occurred in a foxhound pack in New Zealand in 2010, 2011 and 2012; freshly slaughtered horse carcases, destined to be hound food, were hung within metres of the hounds' runs and could have attracted biting flies. Two other cases occurred in two hunt clubs on the outskirts of Melbourne in 1992. While 50 km apart, some hounds from each hunt had met at a joint event. Another case occurred in foxhounds in Georgia, USA, in 2002	Smits *et al.* (2012)
Heartworm in Canada	The first case of *Dirofilaria immitis* in a Canadian-born dog was an American foxhound from Stratford, Ontario. The parasite had been contracted from a pair of foxhounds imported from Illinois two years earlier. The case highlighted the risks of importing hounds and moving them around for international field trials and dog shows	Nielsen (1954)

Parasite/disease	History	Source
Heartworm in the US	Of 102 foxhounds examined from three hunt clubs in Maryland, 45 were infected with *Dirofilaria immitis* microfilariae	Mallack *et al.* (1971)
***Hepatozoon* in the Czech Republic**	Of eight dogs used to hunt foxes, *Hepatozoon* DNA was detected in four, and in 20/21 red foxes from the same area. There was no known vector in the area, and so there must have been cross infection between dogs and foxes	Mitková *et al.* (2016)
Leptospirosis in Switzerland	Being in contact with horses and being used for hunting were significant risk factors associated with seropositivity to *Leptospira* serogroups Bratislava and grippotyphosa respectively for dogs	Delaude *et al.* (2017)
***Leptospira interrogans* in the US**	*Leptospira interrogans* (serovars grippotyphosa and ballum) were isolated from an American foxhound puppy, and 23 of 36 adult foxhounds had serovar grippotyphosa	Cole *et al.* (1982)
Paragonimiasis in western Japan	Boar-hunting dogs were infected with *Paragonimus westermani* by being fed wild boar meat and could be a major definitive host maintaining the disease in western Japan. Control measures should include the prohibition of raw meat feeding and regular deworming of hunting dogs	Irie *et al.* (2017)
Swine brucellosis in Australia	Brucellosis, caused by *Brucella suis*, is endemic in feral pigs in Queensland and is spreading to other parts of Australia. Hunting dogs and humans are infected through contact with blood, body fluids or tissue of infected pigs, and hunting dogs are also infected by feeding raw meat and offal from feral pigs. Feral pig hunting is the main risk factor for catching brucellosis in New South Wales. Veterinarians have become infected following surgery on infected dogs	http://theconversation.com/pig-hunting-dogs-and-humans-are-at-risk-of-a-disease-that-can-cause-miscarriages-and-infertility-81171; http://www.health.nsw.gov.au/Infectious/factsheets/Pages/brucellosis-and-pig-hunting.aspx; Massey *et al.* (2011)
Swine brucellosis in the US	Brucellosis is widespread in feral pigs in the US, particularly in the southeast. There has been a significant increase in infected hunting dogs, and non-hunting dogs have also been infected via urine of infected dogs (particularly in kennels), when breeding, or from being fed uncooked meat or scraps	http://www.gon.com/news/kill-feral-hogs-but-handle-them-carefully-for-your-health-and-your-dogs; Leiser *et al.* (2013)
Tick-borne infections in India	Eleven of 17 foxhounds imported to Secunderabad from other parts of India subsequently contracted piroplasmosis and died *Piroplasma gibsoni* (now *Babesia gibsoni*) was first isolated in blood from the foxhounds of the Madras Hunt, and was later found to be common in golden jackals, the main quarry for the hunt. It was such a problem that every hound had to be deticked on returning to the kennels after hunting and exercising. The main vector is the tick *Haemaphysalis bispinosa*	Webb (1906) Symons & Patton (1912); Symons (1926a,b); Groves & Dennis (1972)
Tick-borne infections in Italy	Of 117 healthy hunting dogs in central Italy, 64 (54.7%) had tick-borne bacterial and protozoan infections - 38 (32.5%) screened positive for *Hepatozoon canis,* 24 (20.5%) for *Bartonella vinsonii* subsp. *berkhoffii*, 20 (17.1%) for *Leishmania infantum*, six (5.1%) for *Coxiella burne,* five (4.3%) for *Babesia canis,* three (2.5%) for *Anaplasma phagocytophilum,* and two (1.7%) for *Ehrlichia canis* In southern Italy, 138/1335 hunting dogs were seroreactive to one or more of *Ehrlichia canis* (7.6%), *Anaplasma* spp.(4.4%), *Borrelia burgdorferi* sensu lato (0.3%) and *Dirofilaria immitis* (0.2%). Hunting fur-bearing animals and larger pack sizes were risk factors for *Ehrlichia canis* and *Anaplasma* spp	Ebani *et al.* (2015) Piantedosi *et al.* (2017)
Tick-borne infections in the US	Of 27 Walker hounds (a breed developed from American and English foxhounds to hunt a variety of species, particularly raccoons) in a kennel in North Carolina, 26 were seroreactive to *Ehrlichia* sp., 16 to *Babesia canis,* 25 to *Bartonella vinsonii,* and 22 seroconverted to *Rickettsia rickettsii* antigens. Of 23 tested, eight were seroreactive to *Bartonella henselae,* one to *E. chaffeensis,* and one to *Rickettsia rickettsii* antigen, although none had signs of illness. Kennel dogs with heavy tick exposure can be infected at a high rate with multiple, potentially zoonotic, tick-borne pathogens	Kordick *et al.* (1999)

Parasite/disease	History	Source
***Toxocara canis* in Italy**	Nearly half (48.4%) of the rural dogs examined in the Marche region of Italy were positive for *Toxocara canis* compared to around a quarter (26.2%) of urban dogs; the highest infection rate (64.7%) was in rural hunting dogs	Habluetzel *et al.* (2003)
Trichinellosis in Italy	Wild boar are usually butchered in the field and offal and scraps discarded; hunting dogs (and wildlife) ingest these parts, which include striated muscles (often the whole diaphragm), the ecological niche of the larvae of *Trichinella* spp. Similar problems apply in other parts of the world	Gómez-Morales *et al.* (2016)
Trypanosomiasis in India	African trypanosomiasis (surra or sleeping sickness) is caused by *Trypanosoma evansi*. A pack of healthy foxhounds was imported from England to the Bombay Hunt: shortly afterwards nine contracted surra and died. In 1926/1927 the same hunt imported a pack of 23 couple of foxhounds: they were *obliterated* by surra. While surra is normally transmitted by horse flies, the evidence suggests that the hounds were infected by *breaking up* infected jackals, which also had the disease at the time, or possibly eating an infected carcase	Walley (1893); Ware (1928)
Trypanosomiasis in the US	American trypanosomiasis (Chagas disease) is caused by *Trypanosoma cruzi*. Of 86 working coonhounds from three kennels in south-central Texas (in one kennel hounds had died from Chagas disease), 58% had antibodies to *Trypanosoma cruzi* and 17% had parasite DNA in their blood; outdoor multi-dog kennels in areas with kissing bug vectors pose a high-risk for transmission in dogs. A survey in Texas confirmed the disease in 48 dog breeds, primarily sporting and working dogs	Kjos *et al.* (2008); Curtis-Robles *et al.* (2017)
Vector-borne canine diseases in Korea	Of 229 wild boar or pheasant hunting dogs, 22.3% were serologically positive for *Dirofilaria immitis*, 18.8% for *Anaplasma phagocytophilum*, 6.1% for *Ehrlichia canis* and 2.2% for *Borrelia burgdorferi*. Of 692 urban dogs, 14.6% were serologically positive for *Dirofilaria immitis*; none of the other tick-borne pathogens were detected in urban dogs. These vector-borne pathogens can cause severe disease in humans	Lim *et al.* (2010)
Visceral leishmaniosis in France	Of 50 uninfected beagles introduced into kennels in Cevennes, southern France, a focus of visceral leishmaniasis, 36 (72%) became infected after one season	Dye *et al.* (1993)
Visceral leishmaniosis in Iraq	Visceral leishmaniosis in a pack of foxhounds near Baghdad caused heavy loses	Sheriff (1957)
Visceral leishmaniosis in North America	The first report of the disease in American foxhounds was in Oklahoma in 1980. In spring 2000 the MFHA of America cancelled all foxhunting events after visceral leishmaniosis was identified in 40 foxhound kennels in 23 US states and 2 provinces in Canada. It is widespread in, and mostly recorded in, foxhounds but has been passed to other dogs via blood transfusions. It is limited to dog-to-dog transmission, mainly from mother to pups. Advice on prevention and management includes ensuring that all hounds should be tested twice before being acquired, shipped, or exchanged for breeding, and neutering infected animals to prevent vertical transmission. Some foxhound kennels in North America have adopted a test and elimination approach to try to reduce disease levels. Visceral leishmaniosis may have been introduced to North America by acquiring hounds from hunts in southern Europe	http://www.nytimes.com/2000/08/25/nyregion/newepidemicprovingfatal-tofoxhounds.html; https://www.capcvet.org/capc recommendations/canine leishmaniasis; www.mfha.com/docs/guidebooks/leishmaniasisguide2014.pdf; Anderson *et al.* (1980); Enserink (2000); Anon. (2001); Owens *et al.* (2001); de Freitas *et al.* (2006); Duprey *et al.* (2006); Freeman (2010); Boggiatto *et al.* (2011); Toepp *et al.* (2017)
Zoonotic helminths in Portugal	In Ponte de Lima, Portugal, dogs used to hunt wild boar had a higher prevalence of helminths and a significantly higher risk of being infected with multiple species of helminths; hunting dogs were responsible for most environmental contamination and human disease	Mateus *et al.* (2014)

Disease risks of feeding dead foxes to hounds

Experiences from elsewhere in the world have highlighted the risk of allowing hounds to *break up* the bodies of wild animals they have killed. Prior to the Hunting Act 2004, foxhunts routinely fed dead foxes to their hounds. This *breaking up* of the carcase was considered to be a reward for the hounds and a key part of training hounds to hunt foxes. Some hunts have continued to throw the bodies of dead foxes to their hounds when these are killed accidentally or when they are dug out and killed by the hunt terriermen.

In the tussle between the hounds, the carcase of the fox suffers multiple bite wounds, causing extensive bone fractures and rupture of the thoracic and abdominal cavities. The internal organs are pulled out and eaten by at least some of the hounds, so that all that remains is some of the skin, bones and musculature of the fox (Butterworth, 2000). During the tussle, body fluids such as blood, urine and faeces are spread on the hounds, which subsequently lick themselves clean.

Foxes and hounds are both canids (members of the dog family Canidae) and most of their parasites and pathogens are shared. The parasites and pathogens of wild foxes in Britain and Ireland are summarised in Baker & Harris (2008). In addition to the nematodes and cestodes already discussed, the heartworm *Angiostrongylus vasorum* is of particular note. It was first reported in Cornwall in 1982, from where it has slowly spread northwards (Yamakawa *et al.*, 2009). Foxes are widely assumed to be a reservoir of infection for dogs, and the parasite is endemic in foxes where there is a high incidence in dogs (Morgan *et al.*, 2008). The role of hunting, and feeding fox carcases to hounds, in the spread of heartworm in Britain is unknown, but it is clearly a risk factor.

The pathogens recorded in foxes include *Brucella abortus*, ten serotpyes of *Leptospira* (of which *Leptospira icterohaemorrhagiae* and *Leptospira canicola* are the most common), *Mycobacterium avium paratuberculosis* (the causative agent of Johne's disease), *Mycobacterium bovis*, *Neospora caninum*, *Salmonella infantes* and *Toxoplasma gondii*. All these can be transferred to hounds when they break up the carcases of foxes.

Since the review by Baker & Harris (2008), a number of other parasites and pathogens have been identified in British foxes that pose a risk to hounds. These include the nematode *Trichinella pseudospiralis* (Learmount *et al.*, 2015): elsewhere in Europe hunting dogs play an important role in the epidemiology of *Trichinella* spp. (Gómez-Morales *et al.*, 2016). Similarly, infectious canine hepatitis poses a significant risk to hounds: it has been identified in fox carcases and antibodies were found in 11/58 (19%) of foxes from England and Scotland (Thompson *et al.*, 2010; Philbey & Thompson, 2014).

The virus may be transmitted to dogs through contact with infected excretions such as urine and faeces (Thompson *et al.*, 2010).

Allowing hounds to break up the bodies of dead foxes poses a significant risk of spreading a wide variety of parasites and pathogens to hounds, humans and livestock. However, in the absence of data on parasites and pathogens in hounds, it is currently impossible to quantify that risk. Thus far the focus continues to be on echinococcosis, and another study is underway into the prevalence of *Echinococcus* in packs of hounds, their husbandry and health care (Anon., 2016c). Comparable data are needed on other parasites in packs of hounds that are of economic and public health concern.

In the UK there is a lack of data on general health and disease in packs of hounds since animals that are deemed no longer fit to hunt are routinely culled and destroyed without a *post mortem*, thereby allowing infectious diseases to go unnoticed and spread within the pack. Despite the lack of quantified data, a wide range of diseases, including zoonoses and notifiable diseases, have been recorded in packs of hounds in the UK and elsewhere in the world. A number of risk factors are associated with hunting hounds becoming infected with, and spreading, livestock and other diseases. These include: feeding raw meat and offal; poor standards of kennel hygiene; lack of adequate veterinary care; lack of routine monitoring of disease; close contact with livestock; and interacting with other packs of hounds. Allowing hounds to break up the carcases of wild animals poses a particular risk

Health treatment of hounds

Basic principles

Animal contact carries disease risks but the frequency of most zoonotic diseases can be lessened or eliminated with management practices that serve both humans and dogs (Beck, 2013). Thus appropriate health treatment of all dogs, and especially working dogs, is critical to reducing the risk of infection in dogs and the transmission of disease to humans and livestock.

The general advice for pets is that puppies should be wormed every two to three weeks from the age of two weeks until 12 weeks old, then monthly until they are six months old (**http://www.yourdog.co.uk/Indepth-Dog-Articles/worming-your-dog.html**). Puppies (unlike most mammals) pick up intestinal worms from their mother through the placenta and, after the birth, through the mother's milk and faeces. So it is essential to worm

pregnant bitches from day 40 of pregnancy to two days after the birth using a wormer containing fenbendazole to cover gastro-intestinal tapeworms (*Taenia* spp.) and roundworms (*Toxocara canis*), hookworms (*Uncinaria* spp. and *Ancylostoma caninum*), whipworms (*Trichuris vulpis*) and giardia (*Giardia* spp.) This will not prevent, but will drastically reduce, the transfer of parasites to the puppy. After the birth, the mother can be returned to a three-monthly worming regime. Similar treatments containing fenbendazole are available for puppies (**https://www.medicanimal.com/Understanding-the-Worming-Regime-for-Newborn-Puppies-and-their-Mothers/a/ART111536**). It is also important to treat the mother for fleas, since these are the intermediate host of the common dog tapeworm *Dipylidium caninum*.

Thereafter, due to the zoonotic risk represented by *Toxocara canis*, the European Scientific Counsel Companion Animal Parasites UK & Ireland (ESCCAP) recommends that all UK dogs should be treated for *Toxocara* infection at least every three months to reduce egg shedding (ESCCAP, 2017), or more frequently if there are young children in the household.

Pet dogs that are inclined to scavenge or live in high risk areas may need worming more frequently (**http://www.yourdog.co.uk/Indepth-Dog-Articles/worming-your-dog.html**). Dogs that are hunting or being fed offal or an unprocessed raw diet pose a particular health risk and should be treated once a month year-round for tapeworms and roundworms (ESCCAP, 2017).

Ectoparasites (ticks and fleas) also pose a risk to dogs because of the diseases that they can transmit (page 45). The Kennel Club recommends an integrated flea-control program for dogs, consisting of: (i) a flea adulticide to kill adult fleas on a dog, to be used at the start of a flea management program and then whenever more fleas are seen on the dog; (ii) a flea protection treatment used once a month all through the year to break the flea lifecycle; and (iii) frequent cleaning of floors and the dog's bedding to reduce the environmental flea population (**https://www.thekennelclub.org.uk/getting-a-dog-or-puppy/general-advice-about-caring-for-your-new-puppy-or-dog/general-puppy-health/**). Since hunting dogs pose a particular risk, ESCCAP recommends that they should be checked for ticks at least every 24 hours, and any ticks removed using a suitable tick removal device (ESCCAP, 2017).

Thus the basic advice is that hunting dogs need more regular treatment for internal and external parasites than that recommended for pet dogs.

Veterinary care of American foxhounds

The MFHA of America recommends that hound health programs should be drawn up and a detailed log book or software program used to identify the past and present schedule of vaccinations and worming treatments (Foster & Wood, 2015; Seier & Foster, 2015). The MFHA of America also gives very specific guidelines on the various health treatments that should be given to packs of hounds in their *Foxhound kennel notebook* (**www.mfha.com/docs/guidebooks/kennelnotebook2015.pdf**). Puppies, for instance, should be wormed every fortnight from two to 16 weeks of age and adult hounds should be given a preventative for internal and external parasites once a month (Seier & Foster, 2015). The MFHA of America's recommended vaccination programme for puppies is shown in Box 8 and for adult hounds in Box 9.

Box 8. Vaccination programme recommended for puppies by the Masters of Foxhounds Association of America (Seier & Foster, 2015); not all these vaccinations are relevant to the UK

SIX WEEKS OF AGE

Vaccinations for the first time:-

- Distemper
- Adenovirus (Type II)
- Para-influenza (CP I)
- Parvo
- Corona - may also be included

NINE WEEKS OF AGE

Vaccinations for the second time:-

- Distemper
- Adenovirus (Type II)
- Para-influenza
- Parvo
- Corona - may also be included

TWELVE WEEKS OF AGE

Vaccinations for the third time:-

- Distemper
- Adenovirus (Type II)
- Para-influenza
- Parvo
- Leptospira - to include new strains of Lepto
- Rabies - depending on local requirements
- Bordetella - injectable or oral
- Corona - also frequently included

SIXTEEN WEEKS OF AGE

Recommended additional vaccinations include:-

- Bordetella - injectable or oral
- Leptospira
- Parvo

Box 9. Vaccination programme recommended for adult hounds by the Masters of Foxhounds Association of America (Seier & Foster, 2015); not all these vaccinations are relevant to the UK

One year of age after full series of vaccinations as a puppy

- Rabies
- DHPPV - distemper, hepatitis, para-influenza, parvo
- Leptospirosis - 4 way
- Bordetella - injectable

Annually thereafter

- Leptospirosis - 4 way
- Bordetella - injectable or oral
- Para-influenza

Every three years thereafter

- Distemper
- Hepatitis
- Parvo
- Rabies

Vaccination programmes for British hounds

The situation in Britain is much less transparent. The MFHA simply says that the *Council of Hunting Associations has produced a Code of Practice for Hunt Kennels in light of the Animal Welfare Act 2006 and in so doing have imitated the style of codes that are already in place for other domesticated and farmed animals. This code of practice provides advice for Masters and Hunt Staff on the necessary standards for hound husbandry and the veterinary treatment of kennelled hounds. In producing the Code, the Council of Hunting Association* [sic] *has sought advice from experienced veterinary surgeons and kennel huntsmen on the content of the code of practice* (http://www.mfha.org.uk/component/content/article/26-foxhunting-the-facts/68-definitions-and-understandings-of-welfare-issues/).

While all hunts have a copy of this code in their kennels (http://www.amhb.org.uk/index.php?option=com_content&task=blogsection&id=9&Itemid=44), it is not publicly available and we have been unable to find any reference to a version that supersedes the code issued in 2007. The MFHA inspects kennels every three years (http://www.mfha.org.uk/component/content/section/3), although their kennel inspection form appears to have been changed from a reporting to a self-assessment form (http://www.mfha.org.uk/hunting/kennel-self-assesment-form; http://www.mfha.org.uk/files/KENNEL%20INSPECTIONS%20Form%20Mounted%202013-2014.doc).

So very little information is available on the vaccination programmes for British packs of hounds. The veterinary report on an outbreak of equine influenza A virus (H3N8) in a pack of English foxhounds in September 2002 says that *the hounds had been inoculated with commercially available vaccines against the major canine respiratory and enteric viruses* when they were puppies (≈eight weeks of age), but makes no reference to any subsequent vaccinations (Daly *et al.*, 2008).

The British Small Animal Veterinary Association recommends the following core vaccines for pet dogs: canine distemper virus, canine adenovirus/infectious canine hepatitis, canine parvovirus and leptospirosis. It also recommends *Bordetella bronchiseptica* +/- canine parainfluenza virus (*kennel cough* vaccine) for dogs before kennelling, dog shows and training classes, rabies (a legal requirement for dogs travelling abroad/returning to the UK under the Pet Travel Scheme), canine herpes virus for breeding bitches, leishmaniosis before travelling to endemic areas, and *Borrelia burgodorferi* for dogs at high risk of exposure to Lyme disease (https://www.bsava.com/Resources/Veterinary-resources/Position-statements/Vaccination).

In addition to the core vaccines recommended by the British Small Animal Veterinary Association, some of the additional vaccinations should also be routine for hounds. In 2017 *Horse & Hound* warned that kennel cough will continue to be a problem until hunting grasps the nettle of compulsory vaccination (https://www.pressreader.com/uk/horse-hound/20171102/282166471444660). Hounds are at high risk of collecting ticks and vaccination against Lyme disease is recommended for dogs living in or visiting regions where the risk of tick exposure is high, or where the disease is endemic (https://www.bsava.com/Resources/Veterinary-resources/Scientific-information/Lyme-disease). Treating hounds with acaricides may also help prevent transmission of Lyme disease (https://www.bsava.com/Resources/Veterinary-resources/Scientific-information/Lyme-disease).

Anthelmintic treatment of British hounds

In the 1970s, over half of the 353 registered hunts in Britain responded to a questionnaire survey. Most of the respondents wormed their dogs for tapeworms, normally at the beginning and end of each season, usually with drugs known to be ineffective (Thompson & Smyth, 1975). A kennelman who worked with three packs of foxhounds in Gloucestershire and Wiltshire from 1980 to 2001 mainly used piperazine- and albendazole-based drugs in the 1980s to treat the foxhounds; these compounds have little or no effect against tapeworms. From the mid-1990s, he used praziquantel, the drug of choice for canid tapeworm infections, twice a year to treat the pack of foxhounds where he was then working (Craig *et al.*, 2012).

While *The code of practice* issued by the Council of Hunting Associations in 2007 recommended that hounds should be treated with praziquantel at least twice a year, at the start and end of the hunting season, a 2011 questionnaire survey of 16 foxhunts in England and Wales found that 56% never used a praziquantel-based wormer to treat their hounds, even though 75% of these hunts fed their hounds raw offal from fallen stock including calves, cattle, horses, lambs and sheep (Craig *et al.*, 2012; Lett, 2013). Furthermore, the level of knowledge on hygiene standards, and practices, displayed by kennelmen was at best alarming. One reported that, despite the recommendations made in *The code of practice*, not much had improved regarding the feeding of uncooked livestock offal to the hounds, which included feeding whole horse carcases without any organs removed, and that the worming treatments given to hounds did not include drugs used to eliminate tapeworms. Another kennelman used a combination of Ivomec and Drontal to treat for parasitic worms, and regularly fed the hounds raw liver from fallen stock such as cattle, horses, lambs and sheep. Another kennelman fed his pack raw liver and lungs from fallen stock including horses and sheep, but used Panacur as a worming drug even though it did not contain praziquantel. Five of the 16 kennelmen interviewed said that they did not even know what echinococcosis or hydatid disease was (Lett, 2013).

This lack of knowledge on the disease, and the risks to humans and livestock, may reflect the attitude of the MFHA and the guidance given to hunts. The 2007 Council of Hunting Associations' *Code of practice* does not warn staff that they may be at risk of human echinococcosis (Lett, 2013). When the Director of the MFHA (who was also the Director of the Council of Hunting Associations) was asked for his approval for a questionnaire to be sent to hunt kennels, he requested that the following questions were removed: *Do you know what echinococcosis/hydatid disease is? and If yes, how are humans infected? From dogs, from sheep or from other source?* [sic] When asked why he wanted these questions removed, the Director of the MFHA said that they were *unnecessary* (Lett, 2013).

While the Council of Hunting Associations recommended that hounds should be treated with praziquantel at least twice a year, the hydatid control programme in mid-Wales from 1983-1989 had to dose owned farm dogs every six weeks with praziquantel to have a significant impact on the rate of transmission of *Echinococcus granulosus* (Buishi *et al.*, 2005; Lembo *et al.*, 2013). This programme of treating dogs was coupled with an extensive education programme. As a result, the prevalence of cystic echinococcosis in sheep declined from 23.5% to 10.5% within a three-to-four-year period. After five years of dosing with praziquantel, the prevalence of echinococcosis in dogs was 0% in 1993 (Lembo *et al.*, 2013).

However, the reemergence of *Echinococcus granulosus* in dogs in south-east Wales following the premature end of the supervised dog-dosing control scheme and a reversion to practices such as farmers allowing their dogs to roam free and infrequent (>four-month intervals) dosing of farm dogs with praziquantel (**http://www.wales.nhs.uk/sitesplus/888/page/43882**; Buishi *et al.*, 2005; Lembo *et al.*, 2013), highlights the need for regular treatment of hounds (and farm dogs). The eggs of *Echinococcus granulosus* are highly resistant and can survive on the ground for up to a year (**http://www.wales.nhs.uk/sitesplus/888/page/43882**), so ESCCAP Europe recommends that dogs with access to *Echinococcus* metacestodes need to be treated monthly with praziquantel to reduce environmental contamination (Baneth *et al.*, 2016).

So, even if it was followed by all hunts, the advice given by the Council of Hunting Associations on kennel management would be inadequate to prevent the spread of *Echinococcus granulosus* and other cestodes. Other reports also suggest that the health treatment of British hounds is at best perfunctory. For instance, a retired huntsman advised that the end of the season *is the time to get the hounds all wormed and really sorted out* (Barker, 2012), whereas they should be treated for worms throughout the year. It should also be remembered that hounds pose a risk of disease transmission throughout the year, not only when hunting. Outside the hunting season, and on days when they are not hunting, hounds regularly use the same routes and fields for exercise, leading to very high levels of contamination on particular pastures and along country roads and lanes used by livestock (page 35).

The importance of regular treatments with anthelmintics was highlighted by a study of 52 culled hounds from 10 Irish packs: a third (17/52) had lesions associated with the migration of *Toxocara canis* larvae, characterized by granulomas, some of which contained remnants of the larvae, and subcapsular fibrosis in the kidney, liver, lung and spleen, highlighting the difficulty of eradicating *Toxocara canis* in working hounds (Jahns *et al.*, 2011).

Costs of veterinary care for hounds

A programme of hound health treatment can be a significant drain on hunt resources and, since April 2016, there has been the added cost of microchipping hounds over eight weeks old, which is now compulsory in Britain (**https://www.gov.uk/get-your-dog-microchipped**). A number of hunts have adopted sponsorship schemes to try to offset these costs. The Blankney Hunt has a scheme where £20 sponsorship goes directly towards *vaccinations, wormers, Id chips and much more* (**https://www.blankneyhunt.co.uk/events/hound-sponsorship-day/**). The South Shropshire Hound Sponsorship was set up to contribute towards the costs of vaccinating and microchipping their hounds (**http://www.southshropshirehunt.com/kennels/hound-sponsorship/**), and the Vine and Craven Hunt's hound sponsorship scheme was established to help with funding

their *hound welfare including vaccinations, worming, vets bills, plus any equipment needed in kennels to keep hounds healthy and happy* (http://www.vineandcraven-hunt.co.uk/). In 2016 and 2017 the Jed Forest Hunt used public appeals (http://www.crowdfunder.co.uk/hound-vaccination/; https://www.justgiving.com/crowdfunding/helpthehounds) to try to raise the funds to vaccinate their hounds against kennel cough; the hunt had missed part of the previous three seasons because of recurrent infections. While kennel cough is a central part of hound health care for many hunts because it curbs their activities, it is of minor consequence in terms of disease risk to humans and livestock.

So maintaining basic veterinary standards appears to be a significant drain on hunt resources and the priority seem to be addressing diseases that have the potential to curtail hunting rather than diseases that cause significant losses to livestock farmers and pose a risk to humans.

The MFHA of America publishes detailed health treatment programmes for their hounds, whereas the health treatment programmes for packs of hounds in the UK are not publicly available. This lack of transparency makes it difficult to assess whether the health treatment programmes implemented by UK packs of hounds are adequate. The limited amount of information that is available raises concerns about the vaccination and programmes to treat internal and external parasites of packs of hounds. Despite the significant risks to livestock, humans and the hounds themselves, the key concern of hunts seems to be to prevent diseases such as kennel cough that have the potential to curtail hunting

The economic impact of livestock diseases

In addition to the diseases already covered (page 29), there are a variety of other livestock diseases where hunting with hounds is likely to play a role in their spread. The list below is not exhaustive and is only intended to give an idea of the losses that are incurred by livestock farmers.

Cestodes in sheep

Foxhounds have high prevalences of a number of species of tapeworm (page 36) for which sheep are the intermediate host. *Cysticercus ovis* (sometimes called sheep measles) and *Cysticercus tenuicollis* are the larval stages in sheep of the tapeworms *Taenia ovis* and *Taenia hydatigena* respectively. The consumption of raw meat and offal from sheep carcases had a significant impact on the prevalence of these cestodes (Williams, 1976b).

Hunting poses a high risk that sheep will be infected with tapeworms that cause major economic losses

While *Cysticercus ovis* and *Cysticercus tenuicollis* rarely cause disease in sheep, they have a major economic impact on sheep farmers. Access to grazing land by hunts and the infrequent use of dog cestocides were significant factors associated with high lamb liver rejection rates at abattoirs due to *Cysticercus tenuicollis* (Jepson & Hinton, 1986). In 2012 *Cysticercus ovis* led to 66,500 lambs being rejected and an industry loss of £5 million, and *Cysticercus tenuicollis* was the cause of 742,000 lamb liver rejection in English abattoirs in 2012. While less common, *Cysticercus ovis* can be more economically damaging for farmers because the entire carcase may be rejected for sheep measles (http://www.fwi.co.uk/livestock/infected-farm-dogs-costing-sheep-sector-15m-a-year.htm). In 2014, 8.8% of sheep livers were rejected due to *Cysticercus tenuicollis*, and in 2015 0.61% of the carcases of all the sheep slaughtered in England were rejected for *Cysticercus ovis* and 5.81% for *Cysticercus tenuicollis* (SHAWG, 2017).

The main concern about hydatid disease is the impact on human health rather than the economic impact on the farming industry. From 2000 to the start of 2013, there were 19 confirmed cases in Wales and 77 in England, although a proportion of these cases were acquired abroad (http://www.wales.nhs.uk/sitesplus/888/page/43882).

Johne's disease (paratuberculosis)

The World Organisation for Animal Health (OIE) classifies Johne's disease as of serious economic or public health importance, and is particularly difficult to tackle because the organisms can survive in river water for five months, pond water for nine months, and in soil for 47 months; the spread of infected manure poses a particular risk of disease transmission. The control of Johne's disease is further complicated by the long delay between infection and animals showing signs of disease. Since hares and their predators can become infected and develop lesions (https://johnes.org/handouts/files/Scottish_Report_JD.pdf), beagling and hunting hares with harriers pose a particular risk of spreading the disease.

The disease is significantly under-diagnosed in sheep, but annual mortality rates can be as high as 5-10% in many infected flocks, and in two fallen stock surveys Johne's disease was diagnosed in 6% of ewes (SHAWG,

2017). In 2013 Johne's disease cost the UK cattle industry £13 million (ADAS, 2013).

Toxoplasmosis

While accurate figures are not available, 350,000 people in the UK are estimated to become infected with *Toxoplasma*, and data from the Netherlands and USA suggest that toxoplasmosis is one of the most costly gastrointestinal infections because the infection is widespread in livestock (Advisory Committee on the Microbiological Safety of Food, 2012).

While calves become infected by grazing contaminated pasture, *Toxoplasma* is far less infective to cattle (Andreoletti *et al.*, 2007). In pigs, toxoplasmosis is associated with reproductive disorders such as abortion and premature birth (Andreoletti *et al.*, 2007), and recent changes to more outdoor farming systems may have resulted in an increase in seroprevalence due to increased exposure to other animals and the environment (Advisory Committee on the Microbiological Safety of Food, 2012).

Toxoplasma is a major cause of abortion and stillbirth in sheep and goats. In 2011, 26% of perinatal lamb losses on Welsh sheep farms were attributed to abortions or stillbirths: the three main infectious causes of abortion were *Chlamydia abortus*, toxoplasmosis and *Campylobacter* sp. (SHAWG, 2017), and collectively these are estimated to cost the UK sheep industry £30 million a year. Toxoplasmosis was the second most important cause of abortion in sheep and in the UK is believed to cause the loss of over half-a-million lambs each year, at a cost of £12-24 million (Advisory Committee on the Microbiological Safety of Food, 2012).

A few other examples

Clostridial diseases kill large numbers of sheep every year, with pulpy kidney and lamb dysentery diagnosed most often (Lovatt *et al.*, 2014).

Bovine viral diarrhoea cost the UK cattle industry £36.6 million in 2013, and calf scour (diarrhoea) £11 million: in 2010 over 70% of cattle farms experienced calf deaths from scour. Of these, 30% of cases were due to cryptosporidiosis and 5% to *Escherichia coli*, with *Salmonella* and coccidiosis being less common causative agents (ADAS, 2013).

While the importance of hunts in spreading diseases has long been recognised, it is not possible to estimate the full economic impact of hunting with hounds on human health and the UK livestock sector. For sheep farmers, having hunts on your land is a major risk factor contributing to their economic losses due to cestodes. While hunts play a role in the spread of a number of other livestock diseases, the contribution of hunts is less easy to untangle from the other risk factors

Future risks

The risks of pet travel

Dogs can act as reservoirs for numerous pathogens and, since 90% of these are multihost (Cleaveland *et al.* 2001), they have the potential to spill over into livestock and wild animals.

In February 2000, the UK adopted the Pet Travel Scheme to enable pets with the appropriate documentation to move between the UK and certain countries. This was a significant change since, for the previous century, the Importation of Dogs Act 1901 had made it illegal to import a dog, cat or one of several other named species without the animal first spending six months in quarantine. The scheme was primarily designed to prevent the importation of rabies, with secondary measures to prevent the introduction of *Echinococcus multilocularis* (Fèvre *et al.*, 2006).

The risk of introducing new zoonoses was enhanced when the UK harmonised its pet travel rules with the rest of the EU in January 2012. People could take their dog, cat or ferret in and out of the UK without quarantine so long as they fulfilled the scheme's rules. However, loopholes and poor enforcement led to the introduction of EU Regulation (576/2013) (**https://ec.europa.eu/food/animals/pet-movement/eu-legislation_en**), which came into effect on 29th December 2014 (**https://www.gov.uk/government/news/changes-to-pet-passports-to-strengthen-travel-scheme**; **http://www.pettravel.com/immigration/UnitedKingdom.cfm**).

In 2015, 164,836 dogs entered the UK under the Pet Travel Scheme. Of these, 65,080 dogs were imported from 128 countries, with 91% coming from other EU Member States; 28,344 were imported for commercial purposes. The rest were British owners returning home with their pet (**https://www.thekennelclub.org.uk/our-resources/kennel-club-campaigns/pet-travel/**). However, these are only the recorded figures: the number of illegal imports is unknown but appears to be rising (**http://www.bbc.co.uk/news/uk-england-38825539**). An investigation by the Dogs Trust showed that the scheme is still extensively abused and that this poses a significant risk of introducing new zoonoses to the UK (**https://www.dogstrust.org.uk/news-events/issues-campaigns/puppy-smuggling/puppy-smuggling-scandal**). Their report led to calls for further changes to strengthen the scheme (**https://www.mariacaulfield.co.uk/news/maria-caulfield-mp-calls-changes-pet-travel-scheme**).

Zoonotic risks associated with packs of hounds

Pet travel appears to be introducing exotic species of ticks from Africa and the United States to the UK (Jameson & Medlock, 2011), and this could spread new pathogens to humans, livestock and wildlife (Millán *et al.*, 2016; Twardek *et al.*, 2017). Because hounds hunt through dense cover, they and other working dogs are at high risk of being infected by ticks and tick-borne diseases (page 41): a number of the diseases recorded in hunting hounds in Europe and elsewhere are transmitted by ticks (Table 7). Since some British packs of hounds are regularly taken to hunt in Europe, sometimes jointly with overseas packs, and hounds from Europe come to Britain for joint hunts with British packs (Table 8), there is a significant risk that they will be infected with ticks or exotic tick-borne diseases. ESCCAP UK & Ireland recommend that all dogs entering the UK should be screened for exotic tick-borne diseases, and hunting dogs should be checked for ticks at least every 24 hours, and any ticks removed using a suitable tick removal device (ESCCAP, 2017).

Table 8. Examples of some of the UK packs of hounds that have hunted abroad in recent years

Hunt	Details of hunts undertaken outside the UK	Source
School and college packs of beagles	The school and college packs of beagles have hunted as far away as France	Downds (2015a)
Quantock Staghounds	There was a joint meet with the Equipage de Rivecourt during which 20 couple of hounds (presumably a mixed pack) hunted a stag. Since the report was titled *Another visit to France with the Equipage de Rivecourt,* there were earlier visits	Cunningham & Cunningham (2014)
Quantock Staghounds and the Equipage de Rivecourt	*Since the ban* [which came into effect in February 2005] *there is an exchange of hunting with a pack of staghounds, the Equipage de Rivecourt, based in Picardy, northern France. Two years ago* [presumably 2014] *we took our hounds across the Channel and enjoyed a highly successful meet.* While the report says that there is an exchange of hunting, no details are given of the visits to the UK by the Equipage de Rivecourt	Jackson (2016)
Quantock Staghounds	On 16th November 2015 three horses and 5½ couples of hounds in a stock trailer and small lorry, supported by a chuck wagon, were taken for a joint meet with the Equipage de Rivecourt. On 18th November, the two packs had a joint hunt in the Forêt Domaniale de Laigue. On 20th November some followers went boar hunting and a few joined a pack of roebuck hounds. On 21st November there was another joint staghunt by the two packs	Batten (2015)
Quantock Staghounds	On 6th November 2016 three horses and seven couples of hounds again joined the Equipage de Rivecourt in France. One of the Exmoor foxhounds (Warlock) was due to join the Rivecourt pack in September 2017. The two packs had a joint hunt in the Forêt Domaniale de Laigue on 9th November, *had to be wormed by the vet in Plessis Brion* the next day while some of the 65 Exmoor Staghounds' supporters went hunting wild boar, and on 12th November there was another stag hunt by the joint pack	Anon. (2016d)
Equipage de Selore	In 2017 Baron von Pfetten brought seven couples of foxhounds to hunt with the Belvoir in Lincolnshire; both packs of hounds hunted together	Holliday (2017)

In addition to their hounds, hunts take a number of vehicles and horses when hunting abroad. Trucks, lorries, loading ramps, people and their clothing pose a significant risk of introducing diseases in fomites unless everything has been thoroughly cleaned and disinfected. In this respect, three of the livestock diseases of particular concern are African swine fever, classical swine fever and FMD. African swine fever is transmitted by ticks and can be spread by contaminated fomites: sporadic outbreaks have been recorded in France and other northern European countries. Classical swine fever is a highly contagious disease of pigs spread by fomites, and wild boar play an important epidemiological role in maintaining the infection in Europe (Artois *et al.*, 2002). FMD is of particular concern since the virus can survive for long periods under favourable conditions, and it is difficult to prevent its spread by fomites: a very high standard of cleaning and disinfection of people, vehicles and

equipment is required (Taylor, 2008). Since hunting trips abroad involve visiting areas with high-risk zoonoses, meets with joint packs of hounds, and hunting species such as wild boar that play an important epidemiological role in the spread of a notifiable disease (Table 3), great care has to be taken to ensure that there is no transmission of these diseases on fomites, or introducing tick-borne infections.

Canine babesiosis is one of the tick-borne zoonoses of concern. It is caused by various species of the protozoan genus *Babesia* (Solano-Gallego *et al.*, 2016). It was first recorded in dogs in Harlow, Essex in 2016, and its appearance in the UK is most likely to be due to the relaxation of controls under the EU pet travel scheme (**http://www.bbc.co.uk/news/uk-england-essex-35794126**; **https://www.theguardian.com/lifeandstyle/2016/mar/16/tick-borne-disease-babesiosis-kill-dogs-spread-uk-essex**). Avoidance of known tick areas, particularly during tick seasons, use of an effective anti-tick product and daily checking dogs for, and the effective removal of, ticks may help reduce the risk of disease transmission (**https://www.bsava.com/Resources/Veterinary-resources/Scientific-information/Babesia-canis**). *Babesia annae* has recently been recorded in 46/316 (14.6%) of British foxes (Bartley *et al.*, 2016), highlighting the disease risks of feeding dead foxes to hounds.

There are similar concerns with canine leishmaniosis. At least 2.5 million dogs are infected in southwest Europe, and the disease is spreading northwards. The importation and relocation of dogs from endemic countries is responsible for the growing number of infected dogs in Germany, and there are serious concerns about it being introduced to Britain and Ireland (Goodfellow & Shaw, 2005; Baneth *et al.*, 2008, 2016). Leishmaniosis is widespread in foxhounds in North America, where they are the main breed of dogs maintaining the disease (page 39); they are infected with *Leishmania infantum* MON1, the predominant zymodeme found in infected dogs and humans in southern Europe (**https://www.capcvet.org/capcrecommendations/canineleishmaniasis**). *Leishmania infantum* has also been found in foxes in Europe e.g. 52.2% of foxes from central Italy (Verin *et al.*, 2010), 9% of foxes from southeast France (Davoust *et al.*, 2014) and 59.5% of foxes from central Greece (Karayiannis *et al.*, 2015), further highlighting the risks of feeding dead foxes to hounds. Thus there is every reason to suspect that English foxhounds pose a significant health risk should leishmaniosis be introduced to Britain and Ireland. Despite the risks, the control of leishmaniosis is not well addressed by national and international authorities (Lembo *et al.*, 2013). ESCCAP UK & Ireland recommend that all dogs arriving in the UK should be screened for *Leishmania* spp. (ESCCAP, 2017).

The other zoonosis of particular concern that is relevant to this review is alveolar echinococcosis, caused by *Echinococcus multilocularis*. While the UK is currently free of this parasite (Smith *et al.*, 2003), it is spreading in Europe (Sréter et al., 2004; Kosmider *et al.*, 2012) and there is a significant risk that it will be introduced to Britain (e.g. Kosmider *et al.*, 2012). Foxes are the definitive host, with dogs to a lesser extent; small rodents are the intermediate hosts (**https://www.cdc.gov/parasites/echinococcosis/biology.html**). *Echinococcus multilocularis* is one of the most pathogenic parasitic zoonoses in central Europe (Torgerson & Budke, 2003), and alveolar echinococcosis results in the death of people in 10 to 15 years if untreated (Eckert *et al.*, 2011).

Dogs may play a very important role in the transmission of alveolar echinococcosis to humans, and in those parts of Europe where *Echinococcus multilocularis* is endemic, prevalence levels are higher in hunting hounds and working dogs than companion animals (Table 7). So if alveolar echinococcosis is introduced to Britain, hunting with hounds is likely to contribute to its spread in a number of ways. *Echinococcus* eggs are sticky and adhere to tyres, shoes or animal paws, resulting in widespread contamination of the environment. Since they hunt over large areas, packs of hounds are likely to be a significant factor in the spread of the parasite, as is already the case with *Echinococcus equinus* and *Echinococcus granulosus* (pages 35 and 36). In France, efforts to control *Echinococcus multilocularis* by night-shooting foxes was counter-productive. The prevalence of the parasite in foxes rose from 40% to 55%; there was no change in an area where foxes were not culled. The rise in prevalence was attributed to an increase of juvenile fox movements in the culling area (Comte *et al.*, 2017). Even if foxes are not actually hunted by hounds, the disturbance from packs of hounds operating in the area can encourage them to make long-distance movements (Lloyd, 1980). This has long-been recognised by hunts; one on the key objectives of cubhunting was to spread foxes around the hunt's country (Beaufort, 1980). Because of these risks, the Pet Travel Scheme prescribed a strict deworming regime of all the dogs entering the country to try to prevent the introduction of *Echinococcus multilocularis*.

The Pet Travel Scheme has increased the risk that dogs will introduce novel diseases to Britain. Hunts pose a high risk that they will introduce some of these diseases following reciprocal sporting visits with European countries where they are endemic. Foxhounds pose a particular risk of maintaining leishmaniosis, should the disease be introduced to Britain and/or Ireland. Hunts are also likely to exacerbate the spread of novel parasites such as *Echinococcus multilocularis* by increasing dispersal movements of juvenile foxes. Foxhunts pose an especial risk of transferring and spreading a variety of new pathogens by allowing their hounds to *break up* fox carcases

Conclusions

All aspects of hunting with hounds pose significant biosecurity risks to livestock farmers. The hunt and their followers do not follow basic biosecurity advice, such as disinfecting themselves, their equipment, vehicles, horses and hounds before entering a farm or moving between farms. The risk of disease transmission between farms is enhanced because of the number of people, horses and hounds that are involved, the large distances the hounds cover each day, and because many of the hunt followers are landowners, farmers or agricultural workers, who return to their own farming communities at the end of a day's hunting.

During a day's hunting, the hounds drink from local water supplies, including livestock troughs, hunt in local water sources, travel through areas with farm stock, and defecate in fields used by livestock and for growing vegetable and soft fruit crops. All these activities pose a significant risk of disease transmission to both livestock and humans, and are contrary to the biosecurity advice given by farming and other countryside groups.

There is a high risk of packs of hounds spreading diseases around Britain because of the frequency of *sporting visits* to other hunts' countries. These visits involve transporting vehicles, hounds and horses to hunt in new areas. Hunts also take their hounds to parade in agricultural shows, which may include several different packs, and to show them at national shows, where hounds from a greater number of packs are judged. Examples of the risks of disease transmission can be seen in the spread of kennel cough through British packs of hounds in the recent years, and the rapid spread of leishmaniosis in American foxhounds. Both of these diseases are spread primarily by hound-to-hound contact.

There are substantial risks of feeding raw meat diets to dogs, and veterinary organisations in Britain and North America have all warned against this practice. The risks are heightened for hounds routinely fed raw flesh and offal from fallen stock, and a number of studies have shown that this is associated with high worm burdens in hounds. A wide range of pathogens have also been recorded in British hounds, including notifiable diseases. Similar problems with maintaining and spreading parasites and pathogens have been recorded with hounds and other hunting dogs elsewhere in the world.

While the risks of feeding packs of hounds on raw meat and offal have been highlighted for the last 50 years, hunts continue to use a substantial proportion of Britain's fallen stock to feed their hounds. A wide range of parasites and pathogens have been recorded in fallen stock. Even though the regulations on the use of animal by-products do not allow livestock that have died of a disease that could infect animals or humans to be used for animal feed, fallen stock are routinely fed to hounds without establishing the cause of death. Suitable dried foods are now available which negate the need to collect fallen stock for packs of hounds.

There is no monitoring of ill-health in hounds, and animals unable to hunt with the rest of the pack are routinely culled without establishing the underlying cause. So diseases such as bTB can go undetected in packs of hounds for extended periods. The little evidence that is available suggests that hounds do not receive adequate veterinary treatment. Basic veterinary care for pet dogs costs around £200 per annum for worming treatments every 3 months (£60), monthly flea treatments (£60), vaccinating a puppy against canine distemper, hepatitis, parainfluenza and leptospirosis (£100-£120), with annual boosters (£50-£60), and a one-off cost for microchipping (£15-£20) (**http://www.petwebsite.co.uk/dogs/buying-a-dog/the-cost-of-keeping-a-dog**). Working hounds need more frequent worming and additional vaccinations, such as for kennel cough. Thus the costs for basic veterinary treatments for a pack of 100 hounds are likely to be in excess of £20,000 per annum. While significant, a comprehensive programme of vaccinations and treatment for internal and external parasites is essential to minimise the risk of spreading disease between packs of hounds, to livestock, and to humans. Sponsorship schemes run by some hunts to cover microchipping and vaccinations for their hounds appear to be asking for sums significantly below those that needed for the veterinary care of packs of hounds.

Feeding fallen stock to hounds has long been recognised as maintaining and spreading a number of livestock diseases that have a significant economic impact on farmers. It is not possible to estimate the direct and indirect costs of hunting but, far from being a service, collecting fallen stock is likely to pose a significant financial burden on livestock farmers. There will also be costs of medical care for people and/or their pet dogs that contract parasites and pathogens from hounds during agricultural shows and events where hounds are encouraged to interact with members of the public. The risks are particularly high for children.

With increased pet travel between Britain and Ireland and the rest of the world, there is an increased risk of novel diseases being introduced to Britain and Ireland, especially from Europe. Hunting with hounds is likely to help maintain, and spread, a number of these diseases. Moving packs of hounds between Britain and Europe for joint hunts, which sometimes involve hunting mixed packs, poses a particular risk of introducing new diseases to Britain.

References

Adak, G.K., Cowden, J.M., Nicholas, S. & Evans, H.S. (1995) The Public Health Laboratory Service national case-control study of primary indigenous sporadic cases of campylobacter infection. *Epidemiology and Infection*, **115**, 15-22.

ADAS (2013) Economic impact of health and welfare issues in beef cattle and sheep in England. **http://beefandlamb.ahdb.org.uk/wp-content/uploads/2013/04/Economic-Impact-of-Health-Welfare-Final-Rpt-170413.pdf**.

Advisory Committee on the Microbiological Safety of Food (2009) Ad hoc *group on botulism in cattle, sheep and goats: report on botulism in sheep and goats*. London: Food Standards Agency.

Advisory Committee on the Microbiological Safety of Food (2012) Ad hoc *group on vulnerable groups: risk profile in relation to toxoplasma in the food chain*. London: Food Standards Agency.

Alba, A., Dórea, F.C., Arinero, L., Sanchez, J., Cordón, R., Puig, P. & Revie, C.W. (2015) Exploring the surveillance potential of mortality data: nine years of bovine fallen stock data collected in Catalonia (Spain). *PLoS One*, **10(4)**, e0122547.

Amass, S.F. & Clark, L.K. (1999) Biosecurity considerations for pork production units. *Swine Health and Production*, **7**, 217-228.

Anderson, D.C., Buckner, R.G., Glenn, B.L. & MacVean, D.W. (1980) Endemic canine leishmaniais. *Veterinary Pathology*, **17**, 94-96.

Andreoletti, O., Budka, H., Buncic, S., Colin, P., Collins, J.D., De Koeijer, A., Griffin, J., Havelaar, A., Hope, J., Klein, G., Kruse, H., Magnino, S., López, A.M., McLauchlin, J., Nguyen-Thé, Noeckler, K., Noerrung, B., Maradona, M.P., Roberts, T., Vågsholm, I. & Vanopdenbosch, E. (2007) Surveillance and monitoring of *Toxoplasma* in humans, food and animals: Scientific Opinion of the Panel on Biological Hazards (Question No EFSA-Q-2007-038). *EFSA Journal*, **583**, 1-64.

Anon. (1993) *Skinned! – the secret trade of Britain's huntsmen*. London: League Against Cruel Sports.

Anon. (2001) An uncommon disease in foxhounds. *Bellwether*, **48**, 21.

Anon. (2002) *The Animal By-Products Regulations (EC) No. 1774/2002*. Brussels: European Commission.

Anon. (2004) Biosecurity code for Northern Ireland farms. **https://www.daera-ni.gov.uk/publications/biosecurity-code-northern-ireland-farms**.

Anon. (2007) Survey reveals lack of biosecurity on farms. *Veterinary Record*, **161**, 324-324.

Anon. (2008a) The Dummer Beagles. *Hounds*, **25(1)**, 31.

Anon. (2008b) Sandhurst & Aldershot Beagles. *Hounds*, **25(1)**, 32.

Anon. (2008c) The Weardale and Tees Valley Beagles in Wales. *Hounds*, **25(1)**, 22-23.

Anon. (2010) Eton College Beagles visit Dummer Country. *Hounds*, **26(3)**, 37.

Anon. (2011) Clampdown on illegal disposal. *Farmers Guardian*, **28 January 2011**, 4.

Anon. (2013) Alston 2013. *Hounds*, **30(1)**, 28.

Anon. (2015a) *Tackling dog fouling - report on first national stakeholder event*. **https://www.keepscotlandbeautiful.org/media/845710/ksb-first-national-discussion-on-dog-fouling-final-low-res-041215.pdf**.

Anon. (2015b) Heard it on the grapevine. *Hounds*, **32(1)**, 34.

Anon. (2015c) Peterborough foxhounds. *Hounds*, **31(7)**, 46.

Anon. (2016a) Heard it on the grapevine. *Hounds*, **33(1)**, 16.

Anon. (2016b) Heard it on the grapevine. *Hounds*, **33(2)**, 18.

Anon. (2016c) *Echinococcus* tapeworm infection in livestock and high-risk dog populations. *Hounds*, **33(1)**, 62.

Anon. (2016d) Quantock Staghounds on tour … again. *Hounds*, **33(2)**, 48-50.

Anon. (2017a) Heard it on the grapevine. *Hounds*, **33(8)**, 12.

Anon. (2017b) Heard it on the grapevine. *Hounds*, **33(4)**, 26-27.

Anon. (2017c) Are hunting dogs spreading bovine TB? *Veterinary Record*, **180**, 583.

Antolová, D., Reiterová, K., Miterpáková, M., Dinkel, A. & Dubinsk, P. (2009) The first finding of *Echinococcus multilocularis* in dogs in Slovakia: an emerging risk for spreading of infection. *Zoonoses and Public Health*, **56**, 53-58.

Artois, M., Depner, K.R., Guberti, V., Hars, J., Rossi, S. & Rutili, D. (2002) Classical swine fever (hog cholera) in wild boar in Europe. *Revue Scientifique et Technique*, **21**, 287-303.

Baker, P.J. & Harris, S. (2008) Fox *Vulpes vulpes*. In: Harris, S. & Yalden, D.W. (eds) *Mammals of the British Isles: handbook, 4th edition*, pp. 407-423. Southampton: The Mammal Society.

Baker, P.J., Harris, S. & Webbon, C.C. (2002) Effect of British hunting ban on fox numbers. *Nature*, **419**, 34.

Baneth, G., Koutinas, A.F., Solano-Gallego, L., Bourdeau, P. & Ferrer, L. (2008) Canine leishmaniosis - new concepts and insights on an expanding zoonosis: part one. *Trends in Parasitology*, **24**, 324-330.

Baneth, G., Thamsborg, S.M., Otranto, D., Guillot, J., Blaga, R., Deplazes, P. & Solano-Gallego, L. (2016) Major parasitic zoonoses associated with dogs and cats in Europe. *Journal of Comparative Pathology*, **155**, S54-S74.

Banta, C.A., Clemens, E.T., Krinsky, M.M. & Sheffy, B.E. (1979) Sites of organic acid production and patterns of digesta movement in the gastrointestinal tract of dogs. *Journal of Nutrition*, **109**, 1592-1600.

Barclay, M. (1946) The foxhound. In: Smith, A.C. (ed.) *Hounds & dogs: their care, training & working; for hunting, shooting, coursing, hawking, police purposes, etc.*, pp. 221-228. London: Seeley, Service & Co.

Barker, D. (2010a) Pork pies … again. *Hounds*, **26(6)**, 32-33.

Barker, D. (2010b) Grass yards. *Hounds*, **26(3)**, 36-37.

Barker, D. (2011) Kennel costs. *Hounds*, **27(4)**, 30.

Barker, D. (2012) An old huntsman's thoughts. *Hounds*, **28(4)**, 42-43.

Barsanti, J.A., Walser, M., Hatheway, C.L., Bowen, J.M. & Crowell, W. (1978) Type C botulism in American foxhounds. *Journal of the American Veterinary Medical Association*, **172**, 809-813.

Bartley, P.M., Hamilton, C., Wilson, C., Innes, E.A. & Katzer, F. (2016) Detection of Babesia annae DNA in lung exudate samples from red foxes (*Vulpes vulpes*) in Great Britain. *Parasites & Vectors*, **9**, 84.

Batten, S. (2015) Quantocks en France. *Hounds*, **32(2)**, 30-33.

Bauer, N.B., O'Neill, E., Sheahan, B.J., Cassidy, J. & McAllister, H. (2004) Calcospherite-like bodies and caseous necrosis in tracheal mucus from a dog with tuberculosis. *Veterinary Clinical Pathology*, **33**, 168-172.

Beasley, D.E., Koltz, A.M., Lambert, J.E., Fierer, N. & Dunn, R.R. (2015) The evolution of stomach acidity and its relevance to the human microbiome. *PLoS One*, **10(7)**, e0134116.

Beaufort, Duke of (1980) *Fox-hunting*. Newton Abbot: David & Charles.

Beck, A.M. (2013) The human-dog relationship: a tale of two species. In: Macpherson, C.N.L., Meslin, F.-X. & Wandeler, A.I. (eds) *Dogs, zoonoses and public health*, 2nd edition, pp. 1-12. Wallingford: CABI.

Bevan, L.E.W. (1911) The transmission of African horse-sickness to the dog by feeding. *Veterinary Journal*, **67**, 402-408.

Boggiatto, P.M., Gibson-Corley, K.N., Metz, K., Gallup, J.M., Hostetter, J.M., Mullin, K. & Petersen, C.A. (2011) Transplacental transmission of *Leishmania infantum* as a means for continued disease incidence in North America. *PLoS Neglected Tropical Diseases*, **5(4)**, e1019.

Boillat, C.S., Gaschen, F.P. & Hosgood, G.L. (2010) Assessment of the relationship between body weight and gastrointestinal transit times measured by use of a wireless motility capsule system in dogs. *American Journal of Veterinary Research*, **71**, 898-902.

Boufana, B., Lett, W.S., Lahmar, S., Buishi, I., Bodell, A.J., Varcasia, A., Casulli, A., Beeching, N.J., Campbell, F., Terlizzo, M., McManus, D.P. & Craig, P.S. (2015) *Echinococcus equinus and Echinococcus granulosus sensu stricto* from the United Kingdom: genetic diversity and haplotypic variation. *International Journal for Parasitology*, **45**, 161-166.

Brennan, M.L. & Christley, R.M. (2012) Biosecurity on cattle farms: a study in north-west England. *PLoS One*, **7(1)**, e28139.

Brennan, M.L., Kemp, R. & Christley, R.M. (2008) Direct and indirect contacts between cattle farms in north-west England. *Preventive Veterinary Medicine*, **84**, 242-260.

Bresalier, M. & Worboys, M. (2014) 'Saving the lives of our dogs': the development of canine distemper vaccine in interwar Britain. *British Journal for the History of Science*, **47**, 305-334.

Buishi, I., Walters, T., Guildea, Z., Craig, P. & Palmer, S. (2005) Reemergence of canine *Echinococcus granulosus* infection, Wales. *Emerging Infectious Diseases*, **11**, 568-571.

Burns, L., Edwards, V., Marsh, J., Soulsby, L. & Winter, M. (2000) *Report of the committee of inquiry into hunting with dogs in England & Wales*. London: The Stationery Office.

Butterworth, A. (2000) Post mortem *study of hunted foxes*. Unpublished contract report to the committee of inquiry into hunting with dogs.

Cairns, A. (2007) *The little hunting handbook: everything you wanted to know about hunting but never dared ask (mounted packs only)*. Cirencester: Hunt Staff Benefit Society.

Caldow, G.L. & Graham, M.M. (1998) Abortion in foxhounds and a ewe flock associated with *Salmonella montevideo* infection. *Veterinary Record*, **142**, 138-139.

Caldow, G.L., Crawshaw, M. & Gunn, G.J. (1998) Herd health security in the suckler herd. *Cattle Practice*, **6**, 175-179.

Campbell, F. (2007) *People who litter*. Wigan: ENCAMS. **www.littering-toolbox.ch/files/people_who_litter_litterseg2006_763.pdf**.

Cay, A.B. & Letellier, C. (2009) Isolation of Aujeszky's disease virus from two hunting dogs in Belgium after hunting wild boars. *Vlaams Diergeneeskundig Tijdschrift*, **78**, 194-195.

Chambers, B.J., Smith, K.A. & Pain, B.F. (2000) Strategies to encourage better use of nitrogen in animal manures. *Soil Use and Management*, **16**, 157-161.

Cleaveland, S., Laurenson, M.K. & Taylor, L.H. (2001) Diseases of humans and their domestic mammals: pathogen characteristics, host range and the risk of emergence. *Philosophical Transactions of the Royal Society*, **356B**, 991-999.

Cline, J. & Reynolds, A. (2005) Feeding the canine athlete. *Purina Research Report*, **9(1)**, **https://www.purinaproplanvets.com/media/1463/getresourceaxd-11.pdf**.

Cobham Resource Consultants (1997) *Countryside Sports - their economic, social and conservation significance*. Reading: the Standing Conference on Countryside Sports.

Cole, J.R., Sangster, L.T., Sulzer, C.R., Pursell, A.R. & Ellinghausen, H.C. (1982) Infections with *Encephalitozoon cuniculi* and *Leptospira interrogans*, serovars grippotyphosa and ballum, in a kennel of foxhounds. *Journal of the American Veterinary Medical Association*, **180**, 4357.

Colville, R. (1940) *Beagling and otter-hunting*. London: A & C Black.

Comte, S., Umhang, G., Raton, V., Raoul, F., Giraudoux, P., Combes, B. & Boué, F. (2017) *Echinococcus multilocularis* management by fox culling: an inappropriate paradigm. *Preventive Veterinary Medicine*, **147**, 178-185.

Cook, B.R. (1965) The incidence and epidemiology of *Echinococcus* in Great Britain. University of Liverpool: PhD thesis.

Cook, J. (1826) *Observations on fox-hunting and the management of hounds in the kennel and the field*. London: William Nicol.

Craig, P.S., Woods, M.L., Boufana, B., O'Loughlin, B., Gimpel, J., Lett, W.S. & McManus, D.P. (2012) Cystic echinococcosis in a fox-hound hunt worker, UK. *Pathogens and Global Health*, **106**, 373-375.

Cramer, S.D., Campbell, G.A., Njaa, B.L., Morgan, S.E., Smith, S.K., McLin, W.R., Brodersen, W.B., Wise, A.G., Scherba, G., Langohr, I.M. & Maes, R.K. (2011) Pseudorabies virus infection in Oklahoma hunting dogs. *Journal of Veterinary Diagnostic Investigation*, **23**, 915-923.

Cranley, J.C. (1984) Problems in the post-mortem diagnosis of equine hydatidosis. *Annals of Tropical Medicine and Parasitology*, **78**, 199-203.

Cullen, P.T. (1991) *Farm animal health: a practical guide*. Oxford: Pergamon Press.

Cunningham, I. & Cunningham, J. (2014) Another visit to France with the Equipage de Rivecourt. *Hounds*, **30(8)**, 36-37.

Curtis-Robles, R., Snowden, K.F., Dominguez, B., Dinges, L., Rodgers, S., Mays, G. & Hamer, S.A. (2017) Epidemiology and molecular typing of *Trypanosoma cruzi* in naturally-infected hound dogs and associated triatomine vectors in Texas, USA. *PLoS Neglected Tropical Diseases*, **11(1)**, e0005298.

Daly, J.M., Blunden, A.S., MacRae, S., Miller, J., Bowman, S.J., Kolodziejek, J., Nowotny, N. & Smith, K.C. (2008) Transmission of equine influenza virus to English foxhounds. *Emerging Infectious Diseases*, **14**, 461-464.

Daly, J.M., MacRae, S., Newton, J.R., Wattrang, E. & Elton, D.M. (2010) Equine influenza: a review of an unpredictable virus. *Veterinary Journal*, **189**, 7-14.

Daniels, J.H. & Haight, S.P. (1975) *Feeding working hounds – based on the report on foxhound nutrition by the Masters of Foxhounds Association of America*. Boston, Massachusetts: Masters of Foxhounds Association of America.

Darke, P.G., Roberts, T.A., Smart, J.L. & Bradshaw, P.R. (1976) Suspected botulism in foxhounds. *Veterinary Record*, **99**, 98-99.

Davies, M.E., Hodgman, S.F.J. & Skulski, G. (1957) An outbreak of anthrax in a hound kennel. *Veterinary Record*, **69**, 775.

Davoust, B., Mary, C. & Marié, J.-L. (2014) Detection of *Leishmania* in red foxes (*Vulpes vulpes*) from southeastern France using real-time quantitative PCR. *Journal of Wildlife Diseases*, **50**, 130-132.

Defra (2004) *The Animal Health and Welfare Strategy for Great Britain*. London: Department for Environment, Food and Rural Affairs.

Defra (2006) *Dog control orders - guidance on sections 55 to 67 of the Clean Neighbourhoods and Environment Act 2005*. London: Department for Environment, Food and Rural Affairs.

de Freitas, E., Melo, M.N., da Costa-Val, A.P. & Michalick, M.S.M. (2006) Transmission of *Leishmania infantum* via blood transfusion in dogs: potential for infection and importance of clinical factors. *Veterinary Parasitology*, **137**, 159-167.

Delaude, A., Rodriguez-Campos, S., Dreyfus, A., Counotte, M.J., Francey, T., Schweighauser, A., Lettry, S. & Schuller, S. (2017) Canine leptospirosis in Switzerland - a prospective cross-sectional study examining seroprevalence, risk factors and urinary shedding of pathogenic leptospires. *Preventive Veterinary Medicine*, **141**, 48-60.

Deplazes, P., van Knapen, F., Schweiger, A. & Overgaauw, P.A.M. (2011) Role of pet dogs and cats in the transmission of helminthic zoonoses in Europe, with a focus on echinococcosis and toxocarosis. *Veterinary Parasitology*, **182**, 41-53.

Dixon, J.B., Baker-Smith, J.K. & Greatorex, J.C. (1973) The incidence of hydatid cysts in horses in Great Britain. *Veterinary Record*, **93**, 255.

Downds, A. (2013) Aaron Downd's travels – part four. *Hounds*, **29(5)**, 42-43.

Downds, A. (2015a) Aaron Downds heads for the hills. *Hounds*, **32(1)**, 48-50.

Downds, A. (2015b) Aaron Downds travels. *Hounds*, **31(5)**, 42-43.

Doyle, M.E., Kaspar, C., Archer, J.E. & Klos, R. (2009) White paper on human illness caused by *Salmonella* from all food and non-food vectors. **https://fri.wisc.edu/files/Briefs_File/2014-11-06_1404_FRI_Brief_updateSalmonellaHumanIllness_April2013.pdf**.

Duprey, Z.H., Steurer, F.J., Rooney, J.A., Kirchhoff, L.V., Jackson, J.E., Rowton, E.D. & Schantz, P.M. (2006) Canine visceral leishmaniasis, United States and Canada, 2000–2003. *Emerging Infectious Diseases*, **12**, 440-446.

Dye, C., Vidor, E. & Dereure, J. (1993) Serological diagnosis of leishmaniasis: on detecting infection as well as disease. *Epidemiology and Infection*, **103**, 647-656.

Ebani, V.V., Nardoni, S., Fognani, G., Mugnaini, L., Bertelloni, F., Rocchigiani, G., Papini, R.A., Stefani, F. & Mancianti, F. (2015) Molecular detection of vector-borne bacteria and protozoa in healthy hunting dogs from central Italy. *Asian Pacific Journal of Tropical Biomedicine*, **5**, 108-112.

Eckert, J., Deplazes, P. & Kern, P. (2011) Alveolar echinococcosis (*Echinococcus multilocularis*): and neotropical forms of echinococcosis (*Echinococcus vogeli and Echinococcus oligarthrus*). In: Palmer, S.R., Soulsby, L., Torgerson, P. & Brown, D.W.G. L. (eds) *Oxford textbook of zoonoses: biology, clinical practice, and public health control*, 2nd edition, pp. 669-699. Oxford: Oxford University.

Elsheikha, H. (2013) Update on *Toxocara* biology, diagnosis and human infection. **https://www.vettimes.co.uk**, 4 February 2013.

EnCams (2003) *Dog fouling and the law - a guide for the public*. Wigan: EnCams.

Enserink, M. (2000) Has leishmaniasis become endemic in the U.S.? Science, **290**, 1881-1883.

Enticott, G., Donaldson, A., Lowe, P., Power, M., Proctor, A. & Wilkinson, K. (2011) The changing role of veterinary expertise in the food chain. *Philosophical Transactions of the Royal Society B*, **366**, 1955-1965.

ESCCAP (2017) *Parasite forecast issue 03 July-September 2017*. **http://www.esccapuk.org.uk/docs/Parasite_Forecast_03.pdf**.

EU Scientific Steering Committee (1999) *Scientific opinion on the risks of non conventional transmissible agents, conventional infectious agents or other hazards such as toxic substances entering the human food chain or animal feed chains via raw material from fallen stock and dead animals (including also: ruminants, pigs, poultry, fish, wild/exotic/zoo animals, fur animals, cats, laboratory animals and fish) or via condemned materials*. **https://ec.europa.eu/food/sites/food/files/safety/docs/sci-com_ssc_out53_en.pdf**.

Fagan, J.G. (1990) Aujeszky's disease in a pack of foxhounds. *Irish Veterinary Journal*, **43**, 126.

Fermor, P.S. (2017) The Pennine's forty-second visit to the west country. *Hounds*, **34(1)**, 50.

Fèvre, E.M., Bronsvoort, B.M. de C., Hamilton, K.A. & Cleaveland, S. (2006) Animal movements and the spread of infectious diseases. *Trends in Microbiology*, **14**, 125-131.

Finley, R.L. (2004) Salmonella *in commercially available pig ear treats and raw food diets: prevalence survey and caning feeding trial*. University of Guelph: MSc thesis.

Finley, R., Reid-Smith, R. & Weese, J.S. (2006) Human health implications of *Salmonella*-contaminated natural pet treats and raw pet food. *Clinical Infectious Diseases*, **42**, 686-691.

Finley, R., Ribble, C., Aramini, J., Vandermeer, M., Popa, M., Litman, M. & Reid-Smith, R. (2007) The risk of salmonellae shedding by dogs fed *Salmonella*-contaminated commercial raw food diets. *Canadian Veterinary Journal*, **48**, 69-75.

Fisher, M. (2003) *Toxocara cati*: an underestimated zoonotic agent. *Trends in Parasitology*, **19**, 167-170.

Fogle, B. (2000) *The new encyclopedia of the dog*. London: Dorling Kindersley.

Foster, D.J. & Wood, C.M. (2015) *A guide to being a Master of Foxhounds*. Millwood, VA: MFHA Foundation.

Foxford (1997) Not a fragrant subject – but it's vital. *Horse & Hound*, **30 October 1997**, 52-54.

Freeman, K. (2010) Update on the diagnosis and management of *Leishmania* spp infections in dogs in the United States. *Topics in Companion Animal Medicine*, **25**, 149-154.

Freeman, L.M., Chandler, M.L., Hamper, B.A. & Weeth, L.P. (2013) Current knowledge about the risks and benefits of raw meat–based diets for dogs and cats. *Journal of the American Veterinary Medical Association*, **243**, 1549-1558.

Goodfellow, M. & Shaw, S. (2005) Exotic diseases of dogs and cats at risk of importation to Ireland. *Irish Veterinary Journal*, **58**, 271-277.

Gómez-Morales, M.A., Selmi, M., Ludovisi, A., Amati, M., Fiorentino, E., Breviglieri, L., Poglayen, G. & Pozio, E. (2016) Hunting dogs as sentinel animals for monitoring infections with *Trichinella* spp. in wildlife. *Parasites and Vectors*, **9(154)**, 1-11.

Gore, R., Osborne, A.D., Darke, P.G. & Todd, J.N. (1977) Aujeszky's disease in a pack of hounds. *Veterinary Record*, **101**, 93-95.

Green, R. (2013) Beagling in Ireland. *Countryman's Weekly*, **23 January 2013**, 6.

Greene, C.E. & Gunn-Moore, D.A. (1998) Mycobacterial infections. In: Greene, C.E. (ed.) *Infectious diseases of the dog and cat,* 2nd edition, pp. 313-321. Philadelphia: Saunders.

Groves, M.G. & Dennis, G.L. (1972) *Babesia gibsoni*: field and laboratory studies of canine infections. *Experimental Parasitology*, **31**, 153-159.

Gunn, G.J., Heffernan, C., Hall, M., McLeod, A. & Hovi, M. (2008) Measuring and comparing constraints to improved biosecurity amongst GB farmers, veterinarians and the auxiliary industries. *Preventive Veterinary Medicine*, **84**, 310-323.

Gwyther, C.L., Williams, A.P., Golyshin, P.N., Edwards-Jones, G. & Jones, D.L. (2011) The environmental and biosecurity characteristics of livestock carcass disposal methods: a review. *Waste Management*, **31**, 767-778.

Habluetzel, A., Traldi, G., Ruggieri , S., Attili, A.R., Scuppa, P., Marchetti, R., Menghini, G. & Esposito, F. (2003) An estimation of *Toxocara canis* prevalence in dogs, environmental egg contamination and risk of human infection in the Marche region of Italy. *Veterinary Parasitology*, **113**, 243-252.

Haig, D.A., McIntosh, B.M., Cumming, R.B. & Hempstead, J.F.D. (1956) An outbreak of horsesickness, complicated by distemper, in a pack of foxhounds. *Journal of the South African Veterinary Medical Association*, **27**, 245-249.

Heaton, A. (2012) Alston 2012. *Hounds*, **29(1)**, 34-35.

Heffernan, C., Nielsen, L., Thomson, K. & Gunn, G. (2008) An exploration of the drivers to bio-security collective action among a sample of UK cattle and sheep farmers. *Preventive Veterinary Medicine*, **87**, 358-372.

Hemphill, A., Gottstein, B., Conraths, F.J., De Meerschman, F., Ellis, J.T., Innes, E.A., McAllister, M.M., Ortega-Mora, L.-M., Tenter, A.M., Trees, A.J., Uggla, A., Williams, D.J.L. & Wouda, W. (2000) A European perspective on *Neospora caninum*. *International Journal for Parasitology*, **30**, 877-924.

Higginson, H.A. (1948) *Foxhunting - theory and practice*. London: Collins.

Hobson, J.C.J. (1987) *Beagling*. Newton Abbot: David & Charles.

Holliday, J. (2017) Vive l'Angleterre, vive la différence! *Horse & Hound*, **7 December 2017**, 48.

Holliman, A. (2003) Restocking problems post-FMD. *Cattle Practice*, **11**, 311-312.

Holm, L.P., Hawkins, I., Robin, C., Newton, R.J., Jepson, R., Stanzani, G., McMahon, L.A., Pesavento, P., Carr, T., Cogan, T., Couto, C.G., Cianciolo, R. & Walker, D.J. (2015) Cutaneous and renal glomerular vasculopathy as a cause of acute kidney injury in dogs in the UK. *Veterinary Record*, **176**, 384.

Hosie, B. & Clark, S. (2007) Sheep flock health security. *In Practice*, **29**, 246-254.

Hugoson, G. & Rockborn, G. (1972) On the occurrence of pseudorabies in Sweden. II. An outbreak in dogs caused by feeding abattoir offal. *Zentralblatt für Veterinärmedizin B*, **19**, 641-645.

Humphreys, L. (2008) Strictly come beagling! or … I'm sorry I haven't a clue! *Hounds*, **25(1)**, 61-62.

Hunt, J. (2000) Can British farmers fork out another £2.5m? *Horse & Hound*, **26 October 2000**, 42-45.

Hutchison, M.L., Walters, L.D., Avery, S.M., Synge, B.A. & Moore, A. (2004) Levels of zoonotic agents in British livestock manures. *Letters in Applied Microbiology*, **39**, 207-214.

Hutchison, M.L., Walters, L.D., Moore, A. & Avery, S.M. (2005) Declines of zoonotic agents in liquid livestock wastes stored in batches on-farm. *Journal of Applied Microbiology*, **99**, 58-65.

Irie, T., Yamaguchi, Y., Doanh, P.N., Guo, Z.H., Habe, S., Horii, Y. & Nonaka, N. (2017) Infection with *Paragonimus westermani* of boar-hunting dogs in western Japan maintained via artificial feeding with wild boar meat by hunters. *Journal of Veterinary Medical Science*, **79**, 1419-1425.

Jackson, T. (2016) Hound music in the hills. *Shooting Times & Country Magazine*, **4 May 2016**, 24-26.

Jahns, H., Callanan, J.J., McElroy, M.C., Sammin, D.J. & Bassett, H.F. (2011) Post-mortem findings in Irish culled hounds. *Journal of Comparative Pathology*, **145**, 59-67.

Jameson, L.J. & Medlock, J.M. (2011) Tick surveillance in Great Britain. *Vector-Borne and Zoonotic Diseases*, **11**, 403-412.

Jepson, P.G. & Hinton, M.H. (1986) An inquiry into the causes of liver damage in lambs. *Veterinary Record*, **118**, 584-587.

Jones, A. (1989) Hunt service. In: Wadsworth, W. (ed.) *Vive la chasse – a celebration of British field sports past and present*, pp. 29-49. Brookland, Kent: Dickson Price.

Jones, A. & Walters, T.M.H. (1992a) The cestodes of foxhounds and foxes in Powys, mid-Wales. *Annals of Tropical Medicine and Parasitology*, **86**, 143-150.

Jones, A. & Walters, T.M.H. (1992b) A survey of taeniid cestodes in farm dogs in mid-Wales. *Annals of Tropical Medicine and Parasitology*, **86**, 137-142.

Karayiannis, S., Ntais, P., Messaritakis, I., Tsirigotakis, N., Dokianakis, E. & Antoniou, M. (2015) Detection of *Leishmania Infantum* [sic] in red foxes (*Vulpes vulpes*) in central Greece. *Parasitology*, **142**, 1574-1578.

Kirby, M., Brizuela, C. & Wilkinson, R. (2010) Investigation of farmers' perspectives on the disposal of fallen livestock and animal by-products in Great Britain. *Veterinary Record*, **167**, 606-609.

Kirkland, P.D., Finlaison, D.S., Crispe, E. & Hurt, A.C. (2010) Influenza virus transmission from horses to dogs, Australia. *Emerging Infectious Diseases*, **16**, 699-702.

Kjos, S.A., Snowden, K.F., Craig, T.M., Lewis, B., Ronald, N. & Olson, J.K. (2008) Distribution and characterization of canine Chagas disease in Texas. *Veterinary Parasitology*, **152**, 249-256.

Koehn, C.J. (1942) *Practical dog feeding*. Auburn: Alabama Polytechnic Institute.

Kordick, S.K., Breitschwerdt, E.B., Hegarty, B.C., Southwick, K.L., Colitz, C.M., Hancock, S.I., Bradley, J.M., Rumbough, R., McPherson, J.T. & MacCormack, J.N. (1999) Coinfection with multiple tick-borne pathogens in a Walker hound kennel in North Carolina. *Journal of Clinical Microbiology*, **37**, 2631-2638.

Kosmider, R., Gale, P., Paterson, A., Voas, A., Mount, L. & Roberts, H. (2012) *What is the risk of introducing* Echinococcus multilocularis *to the UK wildlife population by importing European beavers which subsequently escape or are released? Qualitative Risk Assessment*. London: Defra.

Learmount, J., Boughtflower, V., Allanson, P.C., Hartley, K.M., Gutierrez, A.B., Stephens, N.A., Marucci, G. & Smith, G.C. (2015) First report of *Trichinella pseudospiralis* in a red fox in mainland Britain. *Veterinary Parasitology*, **208**, 259-262.

Leiser, O.P., Corn, J.L., Schmit, B.S., Keim, P.S. & Foster, J.T. (2013) Feral swine brucellosis in the United States and prospective genomic techniques for disease epidemiology. *Veterinary Microbiology*, **166**, 1-10.

LeJeune, J.T. & Hancock, D.D. (2001) Public health concerns associated with feeding raw meat diets to dogs. *Journal of the American Veterinary Medical Association*, **219**, 1222-1225.

Lembo, T., Craig, P.S., Miles, M.A., Hampson, K.R. & Meslin, F.-X. (2013) Zoonoses prevention, control, and elimination in dogs. In: Macpherson, C.N.L., Meslin, F.-X. & Wandeler, A.I. (eds) *Dogs, zoonoses and public health*, 2nd edition, pp. 205-258. Wallingford: CABI.

Leonard, E.K., Pearl, D.L., Finley, R.L., Janecko, N., Peregrine, A.S., Reid-Smith, R.J. & Weese, J.S. (2011) Evaluation of pet-related management factors and the risk of *Salmonella* spp. carriage in pet dogs from volunteer households in Ontario (2005–2006). *Zoonoses and Public Health*, **58**, 140-149.

Lett, W.S. (2013) *Detection of* Echinococcus granulosus *and* Echinococcus equinus *in dogs and epidemiology of canine echinococcosis in the UK*. University of Salford: PhD thesis (**http://usir.salford.ac.uk/29558/**).

Lim, S., Irwin, P.J., Lee, S.-R., Oh, M.-H., Ahn, K.-S., Myung, B.-Y. & Shin, S.-S. (2010) Comparison of selected canine vector-borne diseases between urban animal shelter and rural hunting dogs in Korea. *Parasites & Vectors*, **3(32)**, **https://doi.org/10.1186/1756-3305-3-32**.

Lloyd, H.G. (1980) *The red fox*. London: Batsford.

Lloyd, J.I. (1954) *Beagling*. London: Herbert Jenkins.

Lonsir, A. (2013) Al Lonsir follows the packs to the north. *Hounds*, **30(1)**, 46-47.

Lovatt, F.M. & Strugnell, B.W. (2013) An observational study involving ewe postmortem examination at a fallen stock collection centre to inform flock health interventions. *Veterinary Record*, **172**, 504-506.

Lovatt, F., Stevenson, H. & Davies, I. (2014) Sudden death in sheep. *In Practice*, **36**, 409-417.

Lowe, C.N., Williams, K.S., Jenkinson, S. & Toogood, M. (2014) Environmental and social impacts of domestic dog waste in the UK: investigating barriers to behavioural change in dog walkers. *International Journal of Environment and Waste Management*, **13**, 331-347.

Macdonald, D.W. & Johnson, P.J. (1996) The impact of sport hunting: a case study. In: Taylor, V.J. & Dunstone, N. (eds) *The exploitation of mammal populations*, pp. 160-207. London: Chapman & Hall.

Mallack, J., Sass, B. & Ludlam, K.W. (1971) *Dirofilaria immitis* in hunting dogs from an area in Maryland. *Journal of the American Veterinary Medical Association*, **159**, 177-179.

Massey, P.D., Polkinghorne, B.G., Durrheim, D.N., Lower, T. & Speare, R. (2011) Blood, guts and knife cuts: reducing the risk of swine brucellosis in feral pig hunters in north-west New South Wales, Australia. *Rural and Remote Health*, **11(4)**, 1-9.

Mateus, T.L., Castro, A., Ribeiro, J.N. & Vieira-Pinto, M. (2014) Multiple zoonotic parasites identified in dog feces collected in Ponte de Lima, Portugal – a potential threat to human health. *International Journal of Environmental Research and Public Health*, **11**, 9050-9067.

Mattisson, J., Rauset, G.R., Odden, J., Andrén, H., Linnell, J.D.C. & Persson, J. (2016) Predation or scavenging? Prey body condition influences decision-making in a facultative predator, the wolverine. *Ecosphere*, **7(8)**, e01407.

McCallan, L., McNair, J. & Skuce, R. (2014) *A review of the potential role of cattle slurry in the spread of bovine tuberculosis*. **https://www.daera-ni.gov.uk/publications/review-potential-role-cattle-slurry-spread-bovine-tuberculosis**.

McGarry, J.W., Stockton, C.M., Williams, D.J.L. & Trees, A.J. (2003) Protracted shedding of oocysts of *Neospora caninum* by a naturally infected foxhound. *Journal of Parasitology*, **89**, 628-630.

Mee, J.F., Geraghty, T., O'Neill, R. & More, S.J. (2012) Bioexclusion of diseases from dairy and beef farms: Risks of introducing infectious agents and risk reduction strategies. *Veterinary Journal*, **194**, 143-150.

Meier, R.K., Ruiz-Fons, F. & Ryser-Degiorgis, M.-P. (2015) A picture of trends in Aujeszky's disease virus exposure in wild boar in the Swiss and European contexts. *BMC Veterinary Research*, **11(277)**, doi: **10.1186/s12917-015-0592-5**.

Millán, J., Proboste, T., Fernández de Mera, I.G., Chirife, A.D., de la Fuente, J. & Altet, L. (2016) Molecular detection of vector-borne pathogens in wild and domestic carnivores and their ticks at the human-wildlife interface. *Ticks and Tick-borne Diseases*, **7**, 284-290.

Mitková, B., Hrazdilová, K., Steinbauer, V., D'Amico, G., Mihalca, A.D. & Modrý, D. (2016) Autochthonous *Hepatozoon* infection in hunting dogs and foxes from the Czech Republic. *Parasitology Research*, **5**, 4167-4171.

Morgan, E.R., Tomlinson, A., Hunter, S., Nichols, T., Roberts, E., Fox, M.T. & Taylor, M.A. (2008) *Angiostrongylus vasorum* and *Eucoleus aerophilus* in foxes (*Vulpes vulpes*) in Great Britain. *Veterinary Parasitology*, **154**, 48-57.

Morley, P.S., Strohmeyer, R.A., Tankson, J.D., Hyatt, D.R., Dargatz, D.A. & Fedorka-Cray, P.J. (2006) Evaluation of the association between feeding raw meat and *Salmonella enterica* infections at a greyhound breeding facility. *Journal of the American Veterinary Medical Association*, **228**, 1524-1532.

Murdoch, R.S. (1990) Aujeszky's disease in foxhounds. *Veterinary Record*, **126**, 226.

Nash, J.Q., Chissel, S., Jones, J., Warburton, F. & Verlander, N.Q. (2005) Risk factors for toxoplasmosis in pregnant women in Kent, United Kingdom. *Epidemiology and Infection*, **133**, 475-483.

National Association of State Public Health Veterinarians, Inc. (2011) Compendium of measures to prevent disease associated with animals in public settings, 2011. *Morbidity and Mortality Weekly Report*, **60 (4)**, 1-24.

Naziri, Z., Derakhshandeh, A., Firouzi, R., Motamedifar, M. & Tabrizi, A.S. (2016) DNA fingerprinting approaches to trace *Escherichia coli* sharing between dogs and owners. *Journal of Applied Microbiology*, **120**, 460-468.

Newton, R., Cooke, A., Elton, D., Bryant, N., Rash, A., Bowman, S., Blunden, T., Miller,J., Hammond, T.A., Camm, I. & Day, M. (2007) Canine influenza virus: cross-species transmission from horses. *Veterinary Record*, **161**, 142-143.

Nielsen, L.B. (1954) Canine filariasis in Canada – report of a case. *Canadian Journal of Comparative Medicine*, **18**, 370-372.

Oliver, L.-A. (2017) On-farm postmortem examinations. **https://www.vettimes.co.uk/article/on-farm-postmortem-examinations/**.

Orendi, D. (2012) *Fox hunting – the debate in context*. Saarbrücken: AV Akademikerverlag GmbH.

Otero-Abad, B. & Torgerson, P.R. (2013) A systematic review of the epidemiology of echinococcosis in domestic and wild animals. *PLoS Neglected Tropical Diseases*, **7(6)**, e2249.

Owens, S.D., Oakley, D.A., Marryott, K., Hatchett, W., Walton, R., Nolan, T.J., Newton, A., Steurer, F., Schantz, P. & Giger, U. (2001) Transmission of visceral leishmaniasis through blood transfusions from infected English foxhounds to anemic dogs. *Journal of the American Veterinary Medical Association*, **219**, 1076-1083.

Packer, R. (2006) *The politics of BSE*. Basingstoke: Palgrave Macmillan.

Paget, O.J. (1931) *Beagling and beagles*. London: Witherby.

Palmer, A.C. & Medd, R.K. (1981) Hound ataxia. *Veterinary Record*, **109**, 43.

Palmer, A.C., Medd, R.K. & Wilkinson, G.T. (1984) Spinal cord degeneration in hound ataxia. *Journal of Small Animal Practice*, **25**, 139-148.

Phelps, R., Allen, W.R. & Harrop, S.R. (1997) *Report of a review of hunting with hounds*. London: The Stationery Office.

Philbey, A.W. & Thompson, H. (2014) Infectious canine hepatitis in free-ranging red foxes (*Vulpes vulpes*). *Journal of Comparative Pathology*, **150**, 84.

Piantedosi, D., Neola, B., D'Alessio, N., Di Prisco, F., Santoro, M., Pacifico, L., Sgroi, G., Auletta, L., Buch, J., Chandrashekar, R., Breitschwerdt, E.B. & Veneziano, V. (2017) Seroprevalence and risk factors associated with *Ehrlichia canis, Anaplasma* spp., *Borrelia burgdorferi* sensu lato, and *D. immitis* in hunting dogs from southern Italy. *Parasitology Research*, **116**, 2651-2660.

Pritchard, G., Dennis, I. & Waddilove, J. (2005) Biosecurity: reducing disease risks to pig breeding herds. *In Practice*, **27**, 230-237.

Rolfe, V.E., Adams, C.A., Butterwick, R.F. & Batt, R.M. (2002) Relationship between faecal character and intestinal transit time in normal dogs and diet-sensitive dogs. *Journal of Small Animal Practice*, **43**, 290-294.

Rossi, G., Smith, R.L., Pongolini, S. & Bolzoni, L. (2017a) Modelling farm-to-farm disease transmission through personnel movements: from visits to contacts, and back. *Scientific Reports*, **7**, 2375.

Rossi, G., De Leo, G.A., Pongolini, S., Natalini, S., Zarenghi, L., Ricchi, M. & Bolzoni, L. (2017b) The potential role of direct and indirect contacts on infection spread in dairy farm networks. *PLoS Computational Biology*, **13(1)**, e1005301.

Sayers, R. (2009) Reducing risk: biosecurity on dairy farms. *Irish Veterinary Journal*, **62**, 611-616.

Sayers, R.G., Sayers, G.P., Mee, J.F., Good, M., Bermingham, M.L., Grant, J. & Dillon, P.G. (2013) Implementing biosecurity measures on dairy farms in Ireland. *The Veterinary Journal*, **197**, 259-267.

Schlesinger, D.P. & Joffe, D.J. (2011) Raw food diets in companion animals: a critical review. *Canadian Veterinary Journal*, **52**, 50-54.

Scottish Executive (2006) *Responsibility and cost sharing for animal health and welfare: consultation on principles*. Edinburgh: Scottish Executive Environment and Rural Affairs Department.

Scrutator (1858) *Horses and hounds: a practical treatise on their management*. London: George Routledge & Co.

Seier, G.F. & Foster, D. (2015) *Foxhound kennel notebook*, 5th edition. Millwood, Virginia: MFHA Foundation.

SHAWG (2017) Sheep health and welfare report for Great Britain 2016/17. **http://www.eblex.org.uk/returns/health-and-welfare/sheep-health-and-welfare-group-shawg/**.

Sheahan, B.J., Caffrey, J.F., Gunn, H.M. & Keating, J.N. (1991) Structural and biochemical changes in a spinal myelinopathy in twelve English foxhounds and two harriers. *Veterinary Pathology*, **28**, 117-124.

Shepherd, C.B. (1936) Beagling. In: Lonsdale, Earl of (ed.). *Deer, hare & otter hunting*, pp. 25-75. London: Seeley, Service & Co.

Sheriff, D. (1957) Canine visceral leishmaniasis in foxhounds near Baghdad. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **51**, 467.

Smith, G.C., Gangadharan, B., Taylor, Z., Laurenson, M.K., Bradshaw, H., Hide, G., Hughes, J.M., Dinkel, A., Romig, T., & Craig, P.S. (2003) Prevalence of zoonotic important parasites in the red fox (*Vulpes vulpes*) in Great Britain. *Veterinary Parasitology*, **118**, 133-142.

Smits, B., Willis, R., Malik, R., Studdert, V., Collins, D.M., Kawakami, P., Graham, D. & Fyfe, J.A. (2012) Case clusters of leproid granulomas in foxhounds in New Zealand and Australia. *Veterinary Dermatology*, **23**, 465-e88.

Solano-Gallego, L., Sainz, Á., Roura, X., Estrada-Peña, A. & Miró, G. (2016) A review of canine babesiosis: the European perspective. *Parasites & Vectors*, **9**, 336.

Southwell, T. (1927) Experimental infection of the cat and the fox with the adult Echinococcus. *Annals of Tropical Medicine and Parasitology*, **21**, 155-163.

Sréter, T., Széll, Z., Sréter-Lancz, Z. & Varga, I. (2004) *Echinococcus multilocularis* in northern Hungary. Emerging Infectious Diseases, **10**, 1344-1346.

Stallbaumer, M. (1987) The prevalence and epidemiology of cestodes in dogs in Clwyd, Wales. II. Hunting dogs. *Annals of Tropical Medicine and Parasitology*, **81**, 43-47.

Symons, T.H. (1926a) A case of *Spirocerca sanguinolenta* in a foxhound. *Veterinary Journal*, **82**, 472-475.

Symons, T.H. (1926b) Tick-fever due to *Piroplasma gibsoni* Patton in a kennel of foxhounds in India. *Indian Journal of Medical Research*, **14**, 293-315.

Symons, T.H. & Patton, W.S. (1912) Report on an outbreak of canine piroplasmosis due to *Piroplasma gibsoni* (Patton) among the hounds of the Madras Hunt, together with some observations on the treatment of the disease with Salvarsan. *Annals of Tropical Medicine and Parasitology*, **6**, 361-370.

Szczotka-Bochniarz, A., Lipowski, A., Kycko, A., Sell, B., Ziółkowski, M. & Małek, B. (2016) Wild boar offal as a probable source of Aujeszky's disease virus for hunting dogs in Poland. *Journal of Veterinary Research*, **60**, 233-238.

Taylor, N. (2008) *The potential impact of biosecurity targeting endemic disease in reducing risks associated with diseases exotic to UK*. **http://randd.defra.gov.uk/Document.aspx?Document=Appendix10ExoticAnimalDiseaseThreats.pdf**.

Thompson, H., O'Keeffe, A.M., Lewis, J.C.M., Stocker, L.R., Laurenson, M.K. & Philbey, A.W. (2010) Infectious canine hepatitis in red foxes (*Vulpes vulpes*) in the United Kingdom. *Veterinary Record*, **166**, 111-114.

Thompson, R.C.A. (2008) The taxonomy, phylogeny and transmission of *Echinococcus*. *Experimental Parasitology*, **119**, 439-446.

Thompson, R.C.A. & Smyth, J.D. (1974) Potential danger of hydatid disease of horse/dog origin. *British Medical Journal*, **3(5934)**, 807.

Thompson, R.C.A. & Smyth, J.D. (1975) Equine hydatidosis: a review of the current status in Great Britain and the results of an epidemiological survey. *Veterinary Parasitology*, **1**, 107-127.

Toepp, A.J., Schaut, R.G., Scott, B.D., Mathur, D., Berens, A.J. & Petersen, C.A. (2017) *Leishmania* incidence and prevalence in U.S. hunting hounds maintained via vertical transmission. *Veterinary Parasitology: Regional Studies and Reports*, **10**, 75-81.

Toma, L., Stott, A.W., Heffernan, C., Ringrose, S. & Gunn, G.J. (2013) Determinants of biosecurity behaviour of British cattle and sheep farmers - a behavioural economics analysis. *Preventive Veterinary Medicine*, **108**, 321-333.

Torgerson, P.R. & Budke, C.M. (2003) *Echinococcosis* - an international public health challenge. *Research in Veterinary Science*, **74**, 191-202.

Twardek, W.M., Peiman, K.S., Gallagher, A.J. & Cooke, S.J. (2017) Fido, Fluffy, and wildlife conservation: the environmental consequences of domesticated animals. Environmental Reviews, **25**, 381-395.

van der Burgt, G.M., Crawshaw, T., Foster, A.P., Denny, D.J.B. & Schock, A. (2009) *Mycobacterium bovis* infection in dogs. *Veterinary Record*, **165**, 634.

Verin, R., Poli, A., Ariti, G., Nardoni, S., Fanucchi, M.B. & Mancianti, F. (2010) Detection of Leishmania infantum DNA in tissues of free-ranging red foxes (*Vulpes vulpes*) in Central Italy. *European Journal of Wildlife Research*, **56**, 689-692.

von Recum, A.F. (2002) *Hunting with hounds in North America*. Gretna, Louisiana: Pelican Publishing.

Walley, R.S.J. (1893) Surra in fox-hounds. *Journal of Comparative Pathology and Therapeutics*, **6**, 285-286.

Ware, F. (1928) Surra in a pack of foxhounds. *Journal of Comparative Pathology and Therapeutics*, **41**, 249-254.

Waters, A. (2017) Raw diets: are we at a turning point? *Veterinary Record*, **181**, 384.

Webb, E.C. (1906) Piroplasmosis in fox-hounds in India. *Journal of Comparative Pathology and Therapeutics*, **19**, 1-4.

Weese, J.S. & Rousseau, J. (2006) Survival of *Salmonella* Copenhagen in food bowls following contamination with experimentally inoculated raw meat: effects of time, cleaning, and disinfection. *Canadian Veterinary Journal*, **47**, 887-889.

Williams, B.M. (1976a) The epidemiology of adult and larval (tissue) cestodes in Dyfed (U.K.). 2. The cestodes of foxhounds. *Veterinary Parasitology*, **1**, 277-280.

Williams, B.M. (1976b) The epidemiology of adult and larval (tissue) cestodes in Dyfed (U.K.). 1. The cestodes of farm dogs. *Veterinary Parasitology*, **1**, 271-276.

Williams, H.H. (1982) Of men, hounds and hydatidosis - the natural history of a rare disease of man in Wales. *Nature in Wales*, **1**, 30-32.

Wilson, B. & Edwards, P. (1993) Butchery of horse and dog at Witney Palace, Oxfordshire, and the knackering and feeding of meat to hounds during the post-medieval period. *Post-Medieval Archaeology*, **27**, 43-56.

Wolfe, A. & Wright, P. (2003) Human toxocariasis and direct contact with dogs. *Veterinary Record*, **152**, 419-422.

Yamakawa, Y., McGarry, J.W., Denk, D., Dukes-McEwan, J., Macdonald, N., Mas, A., McConnell, F., Tatton, B., Valentine, E.G., Wayne, J., Williams, J.M. & Hetzel, U. (2009) Emerging canine angiostrongylosis in northern England: five fatal cases. *Veterinary Record*, **164**, 149-152.

Zentek, J. & Meyer, H. (1995) Normal handling of diets - are all dogs created equal? *Journal of Small Animal Practice*, **36**, 354-359.