Appendix 8.1 Infectious Diseases

Infection is the colonization of a host animal by organisms. If the infection results in pathological consequences, the infection is termed a disease. Pathogens that cause infectious diseases can be species specific, shared with other species, or zoonotic (transmissible between animals and humans). They can be spread directly from animal to animal, or indirectly via the environment or on other animals. Some pathogens survive in other host species or the environment. Some diseases are caused by the interaction of multiple pathogens (Reeves, 2006).

A8.1.1 Simple pathogen host diseases

These occur when a susceptible animal is exposed to a dose of a specific pathogen that is itself sufficient to cause disease. The disease can be controlled by removing the infected animals (isolation or culling) or by removal of the pathogen (by hygiene practices or by vaccination).

A8.1.2 Viral diseases

Viruses produce disease by replicating inside cells to cause degeneration and cell death (this can cause inflammation and sickness, as described in Section 8.2). For example, infectious bovine rhinotracheitis virus can cause epithelial necrosis and ulceration. Many viruses are very contagious and can cause high mortality. Viruses can be shed in saliva, mucus, aerosols and/or faeces. As the virus in these secretions is frequently inhaled and/or ingested, the primary replication often occurs in the mucosa of the respiratory and/or intestinal tracts (Patel and Heldens, 2009). Other potential routes are ocular, venereal, transplacental and percutaneous (e.g. by biting vectors). The virus can spread to local lymph nodes, or be spread via infected leucocytes to organs such as the liver, kidneys and lungs (viraemia).

The type of cellular damage and the consequences of this damage to physiological function depend on the particular virus and the organs affected; for example, some cause focal haemorrhages (in the liver and kidneys), secretions (in the lungs), oedema and other signs of inflammation that can be readily observed in external mucosa (Patel and Heldens, 2009). Many viruses can damage leucocytes, be immunosuppressive and increase susceptibility to disease. Examples in poultry are infectious bursal disease virus and Marek’s disease virus (Dohms and Saif, 1984). Some viruses, such as equine infectious anaemia virus, can be transmitted mechanically by blood-feeding insects and by ingestion of milk/colostrum. Equine infectious anaemia virus replicates in macrophages in the liver and spleen, causing fever, jaundice, haemolytic anaemia, immune complex glomerulonephritis and organ inflammation oedema (Patel et al., 2012). Other viruses are latent in an animal and only cause disease if the animal is challenged by other infections, stressors and other factors that affect immunocompetence. Feline immunodeficiency virus can cause acute disease that is followed by an immune response that can control the viraemia. However, this is followed by a latent stage during which the immune system is slowly destroyed, leading to immunodeficiency, weight loss, anaemia and increased viral replication (Patel et al., 2012). Feline leukaemia virus causes tumours (lymphomas from infected lymphocytes) and several immune response mediated diseases, including immune complex glomerulonephritis, autoimmune haemolytic anaemia, thrombocytopenia and chronic progressive polyarthritis (Patel et al., 2012).

Viruses are important causes of enteric and respiratory diseases: examples of viral diseases in cattle are bovine viral diarrhoea (BVD) and several viral infections of the respiratory tract, including infectious bovine rhinotracheitis, bovine parainfluenza-3 and bovine syncytial virus. Bovine respiratory syncytial virus can cause severe interstitial
pneumonia. The virus damages the bronchial epithelium causing degeneration, necrosis and hyperplasia. The virus activates macrophages to release cytokines. The bronchioles can fill with mucopurulent exudate. Haemorrhage, oedema and emphysema can occur. These changes can cause coughing, nasal discharges, increased respiration rate, fever and anorexia. If the disease progresses, the bronchi can be obstructed, leading to dyspnoea, depression and coma (Larsen, 2000).

If exotic viruses, that is those that are not normally present in a population, are introduced, they have great potential to spread rapidly in a vulnerable population that does not have adequate immunity to that virus. Vaccination is important in reducing the risk of the spread of endemic and non-endemic viral diseases. Many viral diseases in dogs and cats are controlled by routine vaccination. However, they can be seen in situations such as animal shelters, where many animals without adequate immunity are housed together in a stressful environment. Feline herpesvirus and feline calcivirus are common causes of upper respiratory tract infection. Canine and feline paroviruses can replicate in lymphoid tissues, myocardial cells and small intestinal mucosa to cause haemorrhagic enteritis and myocarditis. Canine distemper virus can affect multiple organs, causing rhinitis, tracheobronchitis, interstitial pneumonia, hyperkeratosis of the nose and foot pads, catarrhal enteritis, necrotizing encephalitis and conjunctivitis (Pesavento and Murphy, 2014).

A8.1.3 Bacterial diseases

Bacterial diseases are common in livestock and can cause a range of clinical conditions with welfare significance, including digestive diseases, respiratory diseases, mastitis, skin diseases, lameness (feet, joint and skeletal problems), abscesses (Fig. 8.8E), sepsicaemia, sepsis, toxæmia and endotoxaemia (Page and Gautier, 2012). Bacteria are responsible for many common poultry diseases of the respiratory system, reproductive tract and skin (Aguos et al., 2013). Bacterial infections can be secondary to or combine with viruses to cause disease.

Pathogenic bacteria cause disease by producing necrosis and pus (mastitis in cattle, strangles in horses, arthritis in pigs and caseous lymphadenitis in sheep, Figs 8.9E and 8.10E); secreting toxins (Escherichia coli can cause acute enterotoxic colibacillosis in pigs, calves and lambs with watery diarrhoea, dehydration and acidosis); or replicating within macrophages and host cells (salmonellosis) (Cheville, 2006). These pathophysiological changes can cause inflammation and sickness, as described in Section 8.2. For example, Actinobacillus pleuropneumoniae can cause severe pneumonia in pigs (Baarsch et al., 2000). Acute-phase proteins and cytokines develop in the serum and lungs, respectively. The alveoli contain fibrinous exudate, blood and necrotic cellular debris, and fluid and fibrin accumulate in the pleural cavity. The pigs can show increased respiratory rate and dyspnoea, vomiting, depression and inappetence. The lungs become consolidated, oedematous and haemorrhagic.
endotoxaemia is commonly associated with failure of passive transfer of colostral antibodies and the subsequent development of septicaemia (Moore and Barton, 2003). Gram-negative bacteria such as *E. coli*, *Mannheimia haemolytica* and *Pasteurella multocida* are common components of neonatal diarrhoea and respiratory disease in calves (Fig. 8.11E). Calves with *E. coli*-induced diarrhoea can develop dehydration due to water and electrolyte losses (Bywater and Logan, 1974). Bacteraemia from *E. coli* can develop into endotoxaemia and sepsicaemia (Ballou et al., 2011). Plasma concentrations of cytokines and acute-phase proteins can increase, and the calves can develop acute hypoglycaemia and leucopenia. The calves can become depressed, lethargic and febrile. Administration of lipopolysaccharide produces similar effects, i.e. increases in cytokine and acute-phase protein concentrations, and sickness, i.e. increases in body temperature, respiration rate and heart rate, and reduced feed intake. This can be followed by respiratory distress, coughing and lateral lying (Plessers et al., 2015).

Mastitis is a common bacterial disease affecting dairy cows, sheep (Fig. 8.12E) and pigs. The inflammatory reaction is a source of pain and discomfort, and some types of mastitis, for example coliform mastitis, can cause sickness (Leslie and Petersson-Wolfe, 2012). Signs of pain and sickness can be reduced by NSAIDs (Vangroenweghe et al., 2005; Fitzpatrick et al., 2013). Some of the signs of pain and sickness seen in cows with *E. coli* mastitis are summarized in Table 8.2.

Stress can alter the growth and/or virulence of bacterial pathogens (Verbrugghe et al., 2012) and the effects of the bacteria on the animal. In piglets, weaning associated with increases in adrenocorticotropic hormone (ACTH) and cortisol can increase the frequency of clinical signs (vomiting, diarrhoea and somnolence) shown in response to the administration of bacterial endotoxin (Kanitz et al., 2002). Repeated social isolation can also affect the severity of some of the clinical responses of piglets to bacterial endotoxin (Tuchserer et al., 2006). Although there are numerous welfare benefits in providing environmental enrichment (Newberry, 1995), it is interesting to note that some types of environmental enrichment provided to some animals can increase the risk of disease after bacterial challenge (Huff et al., 2003).

Antibiotics (the term is used in the broadest sense to include naturally occurring, semi-synthetic and synthetic compounds with antimicrobial activity) are important for the treatment of clinical bacterial infections (therapy), for preventing clinical infections (prophylaxis) (Refsdal, 2000; McEwen, 2006) or for metaphylaxis, i.e. the treatment of a group of animals after the occurrence or diagnosis of clinical disease in part of the group, with the aim of treating the clinically sick animals and controlling the spread of disease to animals in close contact and at risk, or those that may already be subclinically infected (Page and Gautier, 2012; Gleeson and Collins, 2015). However, there are restrictions on antibiotic use in animals because antibiotic resistance is causing major problems in human medicine (Marshall and Levy, 2011). In addition, in many intensive systems, there can be a tendency to use antibiotics to mask disease rather than to correct underlying defects. Routine use of antibiotics in the feed of pigs and broilers to promote growth by controlling subclinical disease has been either banned or discouraged. To rear animals without the use of antibiotics to control bacterial infections and avoid the suffering that can occur due to bacterial diseases requires optimal husbandry, health and disease control measures (Gleeson and Collins, 2015) (see Appendix 8.2 on disease control). Gaucher et al. (2015) reported that it was possible to rear broilers without the use of antibiotic and anticoccidial drugs in the feed or water and to replace them with an anticoccidial vaccine, feed and water supplements and optimized rearing conditions. Although growth was lower, and enteritis occurred, mortality was not significantly different compared with units that used antibiotics.

### A8.1.4 Parasitic diseases

Parasites can cause varying degrees of inflammation, discomfort and anorexia (Kyriazakis et al., 1998). They can stimulate an immune response (McRae et al., 2015), and this can sometimes cause disease that is associated
with sickness (Colditz, 2003; Williams, 2011). In fish, parasites can attach to or cause lesions to the sensory apparatus (eyes, nares, inner ear and lateral line) that have the potential to affect feeding and anti-predator behaviour (Barber, 2007).

Some protozoa can kill host cells; for example, coccidia and cryptosporidia damage intestinal epithelial cells in poultry and young ruminants (Fig. 8.13E) and cause diarrhoea. Babesia, transmitted by ticks, can destroy erythrocytes to cause anaemia in cattle. In pigs, sarcocystis can cause sickness (raised body temperature, increased lying and reduced feeding, drinking and rooting) and muscle damage as it reproduces and migrates through the body (Reiner et al., 2009).

Adult parasitic worms can cause disease by mechanical obstruction of ducts (ascarides in pig intestines); by sucking blood and causing anaemia (Haemonchus contortus in sheep, Fig. 8.14E); and by causing diarrhoea (parasitic gastroenteritis in sheep). Enteric parasites can cause raised plasma cortisol concentration (Prichard et al., 1974; Fleming, 1997) and debilitate animals by causing inappetence, protein loss (from leakage of plasma protein and damage to the lining of the gastrointestinal tract) and weight loss (Holmes, 1987). Larvae

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<th>Table 8.2.</th>
<th>Signs of pain and sickness in bovine <em>Escherichia coli</em> mastitis.</th>
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<td>Pain</td>
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<td></td>
<td>Vangroenweghe et al. (2005)</td>
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<td>Hyperalgesia in infected quarter</td>
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<td>↓ Hind-leg weight shifting</td>
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<td>↓ Lying duration</td>
<td>Cycles et al. (2012)</td>
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<td>Medrano-Galarza et al. (2012)</td>
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<td>Yeiser et al. (2012)</td>
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<tr>
<td>↑ Respiration rate</td>
<td>Banting et al. (2008)</td>
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<td></td>
<td>Vangroenweghe et al. (2005)</td>
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<tr>
<td>↑ Heart rate</td>
<td>Lohuis et al. (1991)</td>
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<td></td>
<td>Vangroenweghe et al. (2005)</td>
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<tr>
<td>↑ Serum cortisol concentration</td>
<td>Zimov et al. (2011)</td>
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Fig. 8.13E. Diarrhoea in young lambs, due to coccidiosis. (Courtesy of Dr Paula Menzies.)
http://www.cabi.org/openresources/90202

Fig. 8.14E. Anaemia in sheep due to *Haemonchus contortus*. (Courtesy of Dr Paula Menzies.)
http://www.cabi.org/openresources/90202
can pass through the body and cause damage (granulomatous lesions) to various organs.

Ticks can transmit a variety of different types of pathogens. They also cause direct damage due to toxic effects, irritation, allergy and a general loss of condition. Culicoides (biting midges) can cause serious irritation and transmit pathogenic viruses such as bluetongue. Lice can cause skin irritation. In sheep, the mites (*Poroptes ovis*) that cause sheep scab can cause scratching, inappetence, emaciation and dehydration, and sometimes mortality from secondary infections (Corke and Broom, 1999; Milne et al., 2008). Sheep can also experience skin irritation from sarcoptic mange (Fig. 8.15E). In pigs, mites cause rubbing due to skin irritation (Goyena et al., 2015). In laying hens, red mites can cause irritation, anaemia, reduced growth and occasionally death (Kilpinen et al., 2005). Sea lice erode the skin of farmed fish, causing tissue damage, and may also act as a vector of other diseases (Ashley, 2007).

The treatment and control of parasites are based on the life cycle of the particular parasite. Adult worms lay eggs that pass out of the host animal in the faeces. Some parasites have an intermediate host (snails for liver fluke and earthworms for lungworms in pigs). Because an animal can ingest the parasite while it grazes, control is based on separation of the animal from its faeces or reducing pasture contamination by avoiding overstocking and by grazing rotation. Medicinal products can reduce the numbers of eggs passed in the faeces or kill external parasites. However, parasite resistance to drug use is an increasing problem (Sangster, 2001). Vaccines can stimulate immunity to some parasites (Hein and Harrison, 2005), e.g. lungworm in cattle and coccidia in poultry. Table 8.3 shows the diagnosis of different causes of death in different housing systems for laying hens, and Fig. 8.17E shows cumulative mortality in the different systems.

Sheep fly strike (Wall and Lovatt, 2015) is a painful condition associated with inflammation, irritation and sometimes death. Blowflies lay their eggs on the sheep, and the maggots burrow into the flesh and poison the sheep with the ammonia that they secrete. Sheep experience fever and reduced feed intake, and have raised plasma concentrations of cortisol, cytokines and acute-phase proteins (Colditz et al., 2005). Surgical procedures, such as tail docking and mulesing, that have been used to reduce the risk of fly strike can themselves cause pain (Plant, 2006). The larvae from the sheep nose bot fly, *Oestrus ovis*, can damage the nasal mucosa (Fig. 8.16E).

**Appendix 8.2 Disease Control**

**A8.2.1 Risk factors for disease**

The philosophy that forms the basis for animal health/preventive medicine is that disease ‘prevention is better than cure’ (European Commission, 2007). The maintenance of health status is a constant challenge. Animals are always at risk of infection, and as some existing infectious diseases are controlled, new ones emerge. Endemic infectious diseases remain in an animal population because the existing disease control measures are not effective. Understanding the underlying causes and the mechanisms by which infectious disease spreads is vital to controlling disease. Contagious diseases can be transmitted by direct physical contact with other...
animals, while infectious diseases can be transmitted not only by infected animals but also via air, water, food and many other vectors, including wild mammals and birds, invertebrates, vehicles, humans and environmental contamination.

Thrusfield (2007, p. 22) defines epidemiology as ‘the study of disease in populations and of the factors that affect its occurrence’. Epidemiological methods can be used to identify risk factors for disease, and these techniques are especially useful when dealing with diseases that are multifactorial in nature. Complex, pathogen–animal–environment diseases can be produced by simultaneous infection with one or more pathogens and by interaction between the infectious agents and predisposing, enabling or reinforcing factors. Such factors include the genetics or age of the animal, and their nutrition, environment and management system. An example is bovine respiratory disease (Webster, 1983; Taylor et al., 2010). These complex and multifactorial diseases can occur when the potential pathogen is present in the environment, on or in the animal, but does not cause disease until the equilibrium between pathogen, animal and environment is disturbed (Webster, 1992; Thrusfield, 2007). Control of these types of diseases requires a whole herd/flock approach and consideration of the husbandry, management, nutrition and environment. Examples of poor husbandry that can predispose to disease include overcrowding, mixing of different ages, obtaining animals from several sources, poor air hygiene, poor drainage and bedding, unhygienic food and watering equipment, inappropriate nutrition and inadequate cleaning and disinfection (Sainsbury, 1998). An example of a risk factor for disease was the lower pre-partum feed intake in dairy cows that subsequently developed post-partum metritis compared with the feed intake of cows that remained healthy during the post-partum period (Huzzey et al., 2007). However, an association does not demonstrate causation, and the underlying pathophysiology that links a risk factor to a disease can sometimes be difficult to identify. The post-partum bacterial proliferation in the uterus that results in metritis tends to occur after the endometrium has been damaged by factors such as obstetrical complications and retained fetal membranes (Gilbert, 2016). It is possible that a pre-partum energy deficit as a consequence of the reduced feed intake reduces immunocompetence (Hammond et al., 2006; Galvão et al., 2010) and thereby facilitates bacterial growth or increases the risk of retained fetal membranes (Gilbert, 2016). Whether cows that subsequently develop metritis have a tendency to be less dominant at the feeding bunk – i.e. they are subordinate compared to cows that remain healthy (Huzzey et al., 2007) – resulting in increased pre-partum stress and reduced immunocompetence, is not clear. The basis of health management and disease prevention is the adoption of an integrated approach to the management of a group of animals to rectify underlying problems with the system of production or management on a unit rather than focusing on just the diagnosis and treatment of individual animals (LeBlanc et al., 2006).

A8.2.2 Disease control measures

In most countries, the primary responsibility for the health of animals rests with the owner of the animals. There are many factors influencing the voluntary adoption of disease control measures by individual farmers. In developed countries, some of the main factors include: the perceived risk of specific diseases and the cost of the disease to the individual farmer; the cost-effectiveness and perceived efficacy and practicability of the control
measures; the ability of advisors to transfer the knowledge and understanding of relevant information within the context of the overall operations of the unit, and especially in a participatory manner that facilitates engagement and ownership by the farmer/producer of the design and operation of programmes; the perceived ability to affect change; the effects on the welfare of the animals; and the sense of pride that the producer has in the management of his or her unit (Valeeva et al., 2007; Kristensen and Jakobsen 2011a; Dehove et al., 2012; Main and Mullan, 2012; Whay et al., 2012; Garforth et al., 2013; Alarcon et al., 2014).

In many, but not all, parts of the world, governments take responsibility for securing external borders to prevent outbreaks of exotic diseases, for disease surveillance and, where necessary, control programmes. Collective action from industry can assist by developing coordinated action plans (European Commission, 2007; Bennett, 2012). For example, the Norwegian dairy goat industry's voluntary disease eradication programme to control caprine arthritis encephalitis, caseous lymphadenitis and Johne's disease appears to have produced some measurable improvements in animal welfare (Muri et al., 2016).

In some developing countries, the effectiveness of disease control measures can be limited by economic and other resources, infrastructure problems, knowledge of which diseases are present and their impact, the movement of animals, the presence of disease in wild animals and the lack of effective veterinary services (Perry and Grace, 2009; Weaver et al., 2012; Smith et al., 2014). Other than for the eradication of rinderpest (Anderson et al., 2011), the prevalence of many epidemic and endemic livestock diseases remains problematic in the developing world (Perry et al., 2013).

Legislation and market requirements to conform to farm assurance schemes and product standards can provide motivation to adopt disease control measures (Main and Mullan, 2012). In the EU, welfare codes and legislation require that management risk factors that have the potential to cause health problems in livestock are controlled.

The main approaches used to control infectious diseases in a unit attempt to increase resistance to infection, remove sources of infection and prevent new contacts that result in the transmission of infection. Factors that affect the ability of animals to resist disease include: the genotype and phenotype of the animal; antibody status, affected by passive transfer of maternal antibodies (e.g., colostrum management in neonatal calves, Lorenz et al., 2011) and vaccination programmes; and factors influencing immunosuppression (Dietert et al., 1994), such as social rank (Hessing et al., 1994), stressors (Shini et al., 2010), thermal extremes (Wathes et al., 1989), inadequate nutrition or changes in nutrition (Pluske et al., 2002) and mixed infections (Hoerr, 2010). Breeding to improve resistance to disease is an active area of research (Berry et al., 2011; Bishop and Woolliams, 2014), and is seen as one mechanism to reduce the welfare consequences of disease (Reiner, 2009).

Factors that affect the level of exposure to pathogens include inadequate cleaning and disinfection (Mannion et al., 2007) (Figs 8.18E and 8.19E), high stocking density, housing design and ventilation resulting in poor air quality (Robertson et al., 1990; Hamilton et al., 1999; Stärk, 2000), and exposure to other groups of animals (Maunsell and Donovan, 2008). In the pig and poultry industries, large breeding companies can restrict the sources of breeding stock and the risk of disease transmission. High pig herd health status can be established by interrupting opportunities for disease transmission from the sow to her piglets by obtaining caesarean-derived, colostrum-deprived piglets, removing piglets immediately after farrowing and obtaining piglets from known high health status herds (Reeves, 2006).

A8.2.3 Biosecurity

Biosecurity on animal units is required to reduce the risk of infectious disease occurring or spreading to other animals. Best practice involves relatively prescriptive guidelines designed to prevent disease-causing agents from entering, spreading within or leaving a property and spreading to other units (Ssematimba et al., 2013). However, many individual producers are reluctant to adopt strict biosecurity procedures (Heffernan et al., 2008; Kristensen and Jakobsen, 2011b). This may be due in part to the costs involved in
implementing the measures (Siekkinen et al., 2012), but many other factors influence biosecurity practices on farms (Toma et al., 2013). Interestingly, concern by British cattle and sheep farmers for animal welfare has not been reflected by the adoption of optimal biosecurity practices (Toma et al., 2013). Animals newly brought on to the unit present the greatest risk of infectious disease spread (Mee et al., 2012). Information on their health status should be obtained and the animals isolated for a suitable period. Only essential visitors should be allowed on to certain units such as pig, poultry or laboratory animal sites. They should follow disinfection procedures, wear unit clothing and footwear, avoid visits to other units for an agreed period before and afterwards, and record their visit. Loading facilities and feed bins should be sited at the unit perimeter. Vehicles that visit other units should be kept off the unit wherever possible. Domestic pets and wild animals (birds and rodents) should be discouraged. Free-range poultry flocks might be required to be housed during an outbreak of avian influenza to prevent disease transmission via wild birds (Lister and van Nijhuis, 2012). Animal units should be sited as far as is practicable from other units, as this will reduce the risk of spread of airborne infectious diseases (Stärk, 1999). The animals should be kept in age segregated groups in all-in/all-out systems, with a cleansing and disinfection programme that is documented, implemented and checked for effectiveness (Reeves, 2006). Cleaning and disinfection of animal housing are facilitated by flat, featureless walls and floors, and an absence of internal structure. Enhancements to animal housing to facilitate behaviour can be constrained by concerns about disease transmission associated with social housing, increased contact with excreta, and difficulty cleaning and disinfecting enclosures containing soil and natural and porous materials. Although care should be taken, especially when housing young animals, some disease concerns have not proved to be major obstacles to the adoption of alternative housing (Newberry, 1995).

A8.2.4 Culling to control infectious disease
In many countries, considerable resources have been allocated to control or eradicate important infectious diseases. However, globalization and increased international trade of animals and animal products have increased the risk of disease spread (Thiermann, 2004). Examples are provided by Zepeda et al. (2001), Fèvre et al. (2006) and de La Rocque et al. (2011) of the relationships between animal movement and the spread of infectious disease. The World Organisation for Animal Health (OIE) website (www.oie.int) provides information on current disease distribution throughout the world. The means of dealing with an exotic disease outbreak such as foot-and-mouth disease or avian influenza include early detection of disease, rapid killing of all known infected animals, tracing of all high-risk contacts, application of herd quarantine and movement restrictions, testing of populations at risk and, in some instances, the application of pre-emptive slaughter or strategic vaccination (Whiting, 2003). Although there are different ethical positions (Wright et al., 2010), culling large numbers of animals can be justified on welfare grounds: to eliminate suffering in diseased animals, to prevent suffering in susceptible animals due to the spread of disease; and to prevent welfare problems due to overcrowding or other deteriorating animal husbandry conditions because of movement restrictions (Whiting, 2003; Raj, 2008; East et al., 2014). The killing of large numbers of animals in a short period is difficult to achieve humanely, due to the limited availability of skilled slaughtermen, handling problems, time constraints and, in some cases, the lack of a suitable humane method of killing (Crispin et al., 2002; Whiting, 2003). The animal welfare procedures to be adopted during mass culling are described by Berg (2012), Gavinelli et al. (2014) and OIE (2016).

A8.2.5 Health plans
A written health and welfare plan is a management tool, matched to the individual needs of each livestock unit, that is drawn up in consultation with the unit’s veterinarian, to ensure that preventive and treatment regimes are planned, the health performance is recorded and reviewed and appropriate action plans developed (Main et al., 2003). Health plans form part of many quality assurance schemes, and their presence can be used in welfare assessments as evidence of best practice. Such plans set out health and husbandry activities that cover the whole year’s cycle of production, and include strategies to prevent, treat or limit existing disease problems (both infectious and non-infectious). It is normal practice for stockpeople to undertake routine treatments and disease control measures under the direction of the herd veterinarian (Alban and Agger, 1996). It is therefore important that the plan should provide for regular veterinary visits to advise on animal health and include: standard operating procedures for biosecurity arrangements; procedures for purchased stock; vaccination policy and timing in relation to perceived disease risk (Scott et al., 2007; Richens et al., 2016); isolation procedures; external and internal
parasite control; the timing and dose of any necessary medical treatments; and any specific disease programmes. Important variables are recorded, including the number of animals, age, breed and performance values such as production, water consumption, number of animals found dead, number of culls, treatment and medicine records. A veterinary intervention point is set to decide when normal values have reached an unacceptable level. When the veterinarian visits, clinical notes, post-mortem examinations or laboratory work that has been carried out are added to the health plan. Useful health information can also be recorded using feedback from pathology found at the slaughterhouse during meat inspection (Green et al., 1997; Phythian et al., 2014).

In companion animal practice, regular preventive-medicine consultations, for example during visits for vaccination, provide opportunities for a routine health check, discussion and identification of health issues, and control of parasites and reproduction (Robinson et al., 2016).

A8.2.6 Influence of production system

Each system of husbandry has its characteristic disease problems, but the health of the animals within each system is also dependent on the stockmanship and disease prevention and control measures that are in place. Intensification in the dairy, pig and poultry sectors has provided more opportunities for improved management and control of several endemic diseases (Perry et al., 2013). Intensive systems where the animals are housed can provide greater biosecurity than systems where the animals are kept outside. However, when large numbers of animals are housed on one site, the risk of bacterial and viral diseases (such as enzoonotic pneumonia and enteric disorders in pigs and calves) is high. In general parasitic diseases are more common in extensive systems. For example, in laying hens there is an increased risk of mortality from bacterial diseases, parasites and cannibalism in litter-based and free-range systems compared to cages, but a reduction in viral conditions (Fossum et al., 2009) (Table 8.3). However, in Switzerland, the change from conventional battery cage housing systems to alternative systems was not followed by increased mortality due to coccidia and other parasites. There was a reduction in mortality due to viral diseases, but mortality due to bacterial infection increased. Vaccination against viral diseases and coccidiosis, together with de-worming strategies, paddock rotation, biosecurity and other disease control measures accompanied the changes in housing system (Kaufmann-Bart and Hoop, 2009). Another potential health issue associated with the choice of housing system for laying hens are the greater dust and ammonia concentrations in litter compared with caged systems (David et al., 2015a, b). Weeks et al. (2016) found greater mortality in flocks kept in non-cage systems than in caged systems (Figure 8.17E). For reviews of the health and welfare aspects of different housing systems for laying hens, see Lay et al. (2011) and Lister and van Nijhuis (2012).

Reliable evidence to evaluate the increased risks to animal health and welfare in organic systems of production due to failure to provide standard preventive medicines for disease control is difficult to identify. Comparisons between organic and conventional systems are complicated by confounding factors in each system that affect the risk of disease, e.g. differences in genotype, pasture management. Depending on the type of disease, some diseases have a greater prevalence in organic systems whereas other diseases have a lower prevalence (Kijlstra and Eijck, 2006; Marley et al., 2010; Edwards et al., 2014; Gocsik et al., 2014).

Appendix 8.3 Non-infectious Diseases

A8.3.1 Production-related diseases

Some diseases are considered to have particular welfare significance because they are likely to have occurred as a direct consequence of the management system used (Rollin, 2009), but are tolerated because they do not reduce the economic profitability associated with the management system. Genetic selection has increased production, but in some cases, this has been accompanied by an increased risk of health problems (Rauw et al., 1998). Many metabolic diseases are associated with increased metabolism, rapid growth rate, or high production that results in the failure of a body system because of the increased workload on that organ or system (Julian, 2005).

In general, the selection of dairy cows for increased milk yield leads to a higher risk of mastitis, metabolic diseases and lameness (Oltenacu and Broom, 2010). Metabolic diseases in dairy cattle, such as hypocalcaemia, hypomagnesaemia and ketosis, are associated with imbalances in the input and output of metabolites required for milk production. During early lactation,
dairy cows are in negative energy balance and are susceptible to metabolic and infectious diseases (LeBlanc, 2010).

Cattle offered diets containing insufficient fibre can have an increased risk of developing ruminal acidosis and laminitis (Lean et al., 2008). Milk-fed veal calves have traditionally been reared on milk replacer with a low iron concentration to produce pale-coloured veal with a low myoglobin concentration. A reduction in the availability of iron to form haemoglobin decreases the oxygen-carrying capacity of red blood cells. Unless these veal calves receive additional sources of iron in their diet, the blood haemoglobin concentration is monitored well and, if required, iron supplementation is provided, there is a risk of iron deficiency anaemia. Severe signs can include inappetence, reduced immunity and decreased exercise tolerance (Reece, 1984; Reece and Hotchkiss, 1987; Gygax et al., 1993).

In broilers, difficulty in providing sufficient oxygen to enlarged muscles can cause hypertrophy of the right ventricle of the heart and ascites (Julian, 2000). In layers, osteoporosis is a progressive decrease in mineralized structural bone that leads to bone fragility and susceptibility to spontaneous bone fractures and fractures (Gregory and Wilkins, 1989; Whitehead, 2004). When it occurs later in the laying cycle, it has been called cage-layer fatigue and can cause acute and chronic pain and debility from bone fractures sufficient to cause mortality (Riddell et al., 1968; Webster, 2004). When it occurs later in the laying cycle, it has been called cage-layer fatigue and can cause acute and chronic pain and debility from bone fractures sufficient to cause mortality (Riddell et al., 1968; Webster, 2004). When it occurs later in the laying cycle, it has been called cage-layer fatigue and can cause acute and chronic pain and debility from bone fractures sufficient to cause mortality (Riddell et al., 1968; Webster, 2004). When it occurs later in the laying cycle, it has been called cage-layer fatigue and can cause acute and chronic pain and debility from bone fractures sufficient to cause mortality (Riddell et al., 1968; Webster, 2004). When it occurs later in the laying cycle, it has been called cage-layer fatigue and can cause acute and chronic pain and debility from bone fractures sufficient to cause mortality (Riddell et al., 1968; Webster, 2004). When it occurs later in the laying cycle, it has been called cage-layer fatigue and can cause acute and chronic pain and debility from bone fractures sufficient to cause mortality (Riddell et al., 1968; Webster, 2004). When it occurs later in the laying cycle, it has been called cage-layer fatigue and can cause acute and chronic pain and debility from bone fractures sufficient to cause mortality (Riddell et al., 1968; Webster, 2004).

It has been suggested that several factors associated with increased performance in pigs can predispose to health disorders (Pruinier et al., 2010). Examples include consequences of early weaning on enteric disorders, stress of management practices resulting in reduced immunity, effects of rapid growth on leg disorders, metabolic demands on sows due to lactation and frequency of pregnancy, and increased litter size affecting birth weight and availability of colostrum.

### A8.3.2 Genetic diseases

Many diseases have a genetic component. This can be seen clearly in some purebred dogs. Breed standards for some pedigree dogs may have encouraged breeders to select for characteristics that result in health problems (Asher et al., 2009). Certain features of some breeds (such as coat, weight, skin, eyes and shortness of muzzle) have been exaggerated to the detriment of health, and in some breeds there is an increased prevalence of inherited disorders (Stafford, 2006; Collins et al., 2010; Rooney and Sargan 2010). For example, disorders such as entropion and hip dysplasia (Woolliams et al., 2011) are painful, and they may require surgery or prolonged treatment. In brachiocephalic breeds, their head shape can cause problems during whelping, breathing (Hoareau et al., 2012), exercising (especially in heat) and sleeping (Roedler et al., 2013), and their bulging eyes (exophthalmoses) are susceptible to injury.

### A8.3.3 Neoplastic diseases

Neoplasia is not uncommon in companion animals, especially as they grow old (Sleeckx et al., 2011; Schiffman and Breen, 2015). As tumours grow, they can exert pressure on surrounding tissues and cause pain, e.g. bone marrow tumours (Smith et al., 1972; Cheville, 2006). Tumours on the skin or mucous membranes can ulcerate. Pain can also be caused by direct tumour involvement of pain-sensitive structures such as soft tissue, bone, nerves and viscera, or via bone metastases (Lester and Gaynor, 2000; Gaynor, 2008; Fox, 2012). Malignant tumours grow at the site of origin, and also spread via the circulation and lymphatic system to other sites such as the lungs, liver, spleen and kidneys (Seixas et al., 2011). They can cause ill health (emaciation, anaemia and fatigue) and death.

### A8.3.4 Painful conditions arising from physical changes associated with disease

Pain due to mechanical distension can occur in several clinical situations (Hansen, 2000; Mathews, 2000). When the lumen of the gastrointestinal tract is
Appendix

389

distended due to the accumulation of gas in the stomach or intestine (e.g. bloat due to fermentation, Cheng et al., 1998), gastric (Wingfield et al., 1974) or intestinal torsion, or intestinal obstruction (as occurs in equine colic, Thoefner et al., 2003; Ashley et al., 2005), considerable pain can be caused. Horses with severe colic (potentially fatal) can have raised plasma concentrations of cortisol, ACTH, adrenaline (epinephrine) and β-endorphin (Hinchcliff et al., 2005; Niinistö et al., 2010). When ureteral (kidney stones), urethral (urinary calculi from dietary problems) or biliary (gallstones) ducts are obstructed, fluids accumulate, causing distension and sometimes toxic effects (Catanzaro et al., 2015). Mesenteric, gastric, splenic and testicular torsions (twists) and herniation of intestines into the umbilicus and inguinal canal can cause pain. If blood vessels are blocked (thrombosis), blood can accumulate within the vessel, causing pain due to distention, and fluid can leak into the surrounding tissues, causing swelling and further pain. In situations where the blood supply to an organ is restricted by a pathological process or mechanical obstruction, the tissues are deprived of oxygen (ischaemia) and can become necrotic (Snyder, 1989; Catanzaro et al., 2015). Neuropathic pain (caused or initiated by a primary lesion or dysfunction in the nervous system) can occur. Examples include soft tissue and bony changes that affect the spinal cord (lumbosacral lesions and intervertebral disc herniation), neoplasia and aggressive conditions such as pancreatitis that can damage intrapancreatic nerves (Mathews, 2008).

Appendix 8.3.5 Parturition and neonatal care

Dystocia (difficult birth) caused by fetal oversize or malposition and obstetrical problems such as vaginal or uterine prolapse can be associated with considerable pain, discomfort and health risks (McGuirk et al., 2007; Mainau and Manteca, 2011; Rees, 2016). Veterinary procedures, the use of analgesia and antibiotics, and hygienic practices can reduce the adverse welfare implications associated with obstetrical problems (Scott, 2005). However, they cannot eliminate all of the associated suffering, and if the incidence of dystocia is high, breeding policy should be reviewed. For example, in the double-muscled Belgian Blue breed, calves often have to be delivered by caesarean section, and there is now a case for selecting for smaller calves (Kolkman et al., 2010a,b). Dystocia also causes problems in newborn animals from direct physical trauma, delayed passive antibody transfer and subsequent bacterial infections (Murray and Leslie, 2013). newborn animals are susceptible to mortality from hypothermia, infections, injuries and predation, and require additional care (Mellor and Stafford, 2004).

A8.3.6 Nutrition

Dietary deficiencies, imbalances and contaminants can also cause clinical disease (Fig. 8.20E). Metabolic diseases can occur when animals consume toxic contaminants in their diet, e.g. from fungi, toxic plants or environmental pollution. Obesity is a risk factor for disease. For example, obesity in cats has mechanical and metabolic effects that increase the risk of several diseases, including diabetes mellitus, hepatic lipidosis, urinary tract disease and lameness (Tarkosova et al., 2016).

Fig. 8.20E. Sheep showing signs of polioencephalomalacia (cerebrocortical necrosis), a nervous system disease associated with nutritional factors affecting the availability of thiamine (vitamin B1). (Courtesy of Dr Paula Menzies.)

http://www.cabi.org/openresources/90202

Appendix 8.4 Lameness in Farm and Companion Animals

A8.4.1 Horses

Musculoskeletal injuries are common in horses (Holm and Foreman, 1996), especially in those used in sport (Clegg, 2011, 2012), and they are painful (Ashley et al., 2005). Foot pain is a common cause of lameness, including deep digital flexor tendonitis and lesions of the navicular bone (Dyson et al., 2005). Both horses and cattle (Hoblet and Weiss, 2001) can develop laminitis (Eades, 2010), which results in pathologic changes to the foot that cause severe discomfort, and inflammatory and neuropathic acute and chronic pain (Collins et al., 2010; Driessen et al., 2010). Osteoarthritis can develop in horses as a result of overuse and inappropriate mechanical force on the cartilage in joints. It develops as a result of inflammation of the components of the joint (synovial membrane, cartilage, joint capsule and
subchondral bone), leading to degeneration of articular cartilage (Goodrich and Nixon, 2006).

A8.4.2 Broilers

Lameness in broilers is multifactorial: there are genetic, environmental, nutritional and infectious components. Selection for rapid growth, greater body weight and increased breast muscle has affected broiler shape and walking ability, and increased mechanical stresses on legs and hip joints (Cort et al., 2003a,b). Lame broilers lie down more, walk and feed less than non-lame broilers (Weeks et al., 2000). Reduced time spent exercising by lame broilers and increased time resting increases susceptibility to leg weakness and contact dermatitis (hock burn and breast blisters from poor litter caused by chemical burning from ammonia). Factors associated with difficulty walking include age, genotype, type of feed, short dark periods, high stocking density and not using antibiotics (Knowles et al., 2008). Lameness in poultry is often caused by infection in bone and joints (Butterworth, 1999), so effective prevention and control of viral and bacterial disease is essential on the farm and in the parent flock and hatchery. Common infectious disorders in poultry are osteomyelitis, chondritis and suppurative arthritis (Thorp, 1994). Acute arthritis is likely to be painful (Gentle, 2011). Tibial dyschondroplasia is a growth plate disorder that causes lameness, reduces dust bathing and increases the duration of tonic immobility (Vestergaard and Sanotra, 1999). However, the severity of tibial dyschondroplasia lesions is not always reflected in the gait score, possibly due to the limited innervation of the lesions and especially if complications such as distortion or fracture of the proximal tibia are not present (Garner et al., 2002). Angular deformities of the long bones are frequently accompanied by slippage of the gastrocnemius tendon. Cartilage abnormalities increase the risk of injury and can act as foci for bacterial infections resulting in osteomyelitis. Necrosis and degeneration of cartilage and adjacent bone tissue in the proximal part of the tibia or femur (femoral head necrosis or proximal femoral degeneration) can occur (Waldenstedt, 2006; Packialakshmi et al., 2015).

A8.4.3 Dairy cattle

Most lameness in cattle (Figs 8.21E and 8.22E) originates from foot lesions (sole ulcer, white line disease, digital dermatitis and interdigital necrobacillosis) (Russell et al., 1982; Whay et al., 1998; Dyer et al., 2007). The pain in the feet can be detected by the application of pressure using hoof testers (Dyer et al., 2007), and lame cows can show hyperalgesia (Whay et al., 1997, 1998). Cows with sole ulcers and interdigital necrobacillosis have identifiable changes in their gait/locomotion score (Flower and Weary, 2006; Tadich et al., 2010). Cows with sole ulcer and white line disease can still show hyperalgesia 4 weeks after treatment, whereas those treated for acute digital infections (Whay et al., 1998) or those given an NSAID (Whay et al., 2005) show improvement sooner. Bruijnis et al. (2012) attempted to assess the welfare impact of different types of clinical foot lesions at a herd level by using expert assessment of the impact on locomotion to assess the severity of pain and then multiplying this by the duration and incidence of each condition. The welfare impact of digital dermatitis ranked highest, followed by sole ulcer, interdigital dermatitis and heel erosion, sole haemorrhage, white line disease, interdigital hyperplasia and interdigital foot rot. At the cow level (where only pain severity and duration were considered), the welfare impact was similar for all lesions, except for interdigital foot rot, which was scored very low. Digital dermatitis ranked highest, followed by interdigital dermatitis and heel erosion, interdigital hyperplasia, sole haemorrhage, white line disease and sole ulcer.

Pain reduction in lame cows following either the use of a local anaesthetic nerve block to the feet or administration of an NSAID can improve gait score and reduce weight shifting between legs, but the effects are not dramatic (Rushen et al., 2007; Flower et al., 2008; Chapinal et al., 2010). These modest effects were likely due to variation between the different causes of lameness and/or the increased sensitivity to pain that occurs during chronic lameness (Shearer et al., 2013). Lameness can reduce food intake (Norring et al., 2014) and increase lying behaviour (Ito et al., 2010). Prompt
treatment of lame cows is an important factor in reducing lameness prevalence (Barker et al., 2010). However, the treatment of dairy cows by lateral restraint and claw trimming is stressful (raised blood cortisol concentration and leg movements), and a greater response seen in those lame due to sole ulcer or white line disease may be due to pain following the removal of inflamed corium (Janßen et al., 2016). Other treatment options include reducing weight on the lesion by the application of a foot block to the healthy claw, analgesia and moving the cow to pasture or a sick pen (Shearer et al., 2013). There are many environmental, genetic and nutritional predisposing factors for lameness in dairy cattle (Shearer et al., 2013). For example, reduced lying duration, duration of housing and the types of surfaces on which cattle walk and stand (Barker et al., 2007, 2010; Cook and Nordlund, 2009) are important factors. Gait scoring by external observers has shown that farmers tend to underestimate the prevalence of lameness on their farm (Leach et al., 2010a). The main motivating factors that stimulate farmers to control lameness are pride in their herd, empathy for lame cows, economic losses and public image. Failure of farm accreditation and relative performance compared with other farmers were not considered to be important (Leach et al., 2010b).

After the feet, the joints are the second most common site for causing lameness in cattle. Although the joints can be affected by trauma and developmental conditions (osteoarthritis), bacterial arthritis is more common (Nichols and Lardé, 2014). Bacteria can enter the joints from trauma, adjacent infection or septicaemia. In young calves, a common route of infection is via the umbilicus (Desrochers and Francoz, 2014). Although cattle can develop bursitis, these lesions do not normally cause lameness, but if the swelling is severe and associated with ulceration, they are likely to cause discomfort (Potterton et al., 2011) (Fig. 8.23E).

A8.4.5 Pigs
In sows, lameness can be caused by osteochondrosis, arthritis, abscesses, claw lesions, overgrown claws and leg injuries (Heinonen et al., 2006; Nalon et al., 2013a). Lame sows can show increased sensitivity to mechanical pressure (hyperalgesia) on the affected limb (Nalon et al., 2013b). Sows with overgrown hooves spend less time standing after feeding (Fitzgerald et al., 2012), and growing pigs can have reduced feed intake when lame (Munsterhjelm et al., 2015). In young, lame pigs with arthritis, analgesia improves their gait and activity...
Appendix

392

(Meijer et al., 2015). In growing pigs, osteochondrosis dissecans and infectious arthritis are considered to be the most painful types of lameness (Jensen et al., 2012). In growing pigs, but not in gilts and sows, the severity of calluses, bursitis and capped hock lesions are related to locomotion score (Kilbride et al., 2009). In housed pigs, rough concrete floors and slatted or slotted floors with sharp edges can damage feet and legs, resulting in pain and possibly secondary bacterial infection (Sainsbury, 1998; Heinonen et al., 2006; Kilbride et al., 2009). Secondary infection can spread up the leg from foot lesions to cause tenosynovitis and cellulitis.

A8.4.6 Dogs and cats

In dogs, the pain associated with lameness can affect their ability to perform normal behaviour and their mobility (Hudson et al., 2004). In cats, osteoarthritis is a painful degenerative condition. It is recognized clinically by pain on palpation and/or manipulation, by thickening of individual joints and by characteristic radiographic changes. In addition to lameness, it can cause difficulty in jumping, climbing stairs and resentment of handling. NSAIDs can improve activity, mobility and interaction with the owner (Bennett and Morton, 2009; Slingerland et al., 2011).

Appendix 8.5 Measurement of Disease

Measurement of disease should form part of a welfare assessment of a unit or system. When assessing the welfare relevance of disease and injury, it is important to consider the epidemiology of the condition, the length of time that the animal has been suffering and any treatment or prevention that has been undertaken. The prevalence of a disease is the proportion of animals affected with a disease at any one time. The incidence of a disease is the number of new cases per population at risk that occur in a given period (Thrusfield, 2007). Surveys of disease prevalence are subject to various types of bias, and care is required in their conduct and interpretation (Bartlett et al., 2010). Mortality rates are obviously a relatively crude measurement of health and welfare status. However, morbidity (amount of disease) and mortality rates are useful to assess poor welfare associated with disease and lack of care. Although they cannot be used exclusively as an indication of welfare (Ortiz-Pelaez et al., 2008), morbidity and mortality are useful outcome measurements to identify management risk factors that affect health; for example, see the study on dairy heifers by Johnson et al. (2011). There are different views on the relevance of longevity to animal welfare (Bruijnins et al., 2013), but if death is quick and without suffering it is not considered a welfare issue; however, when it is prolonged and associated with feelings such as sickness, pain and fear, it is a welfare concern (Broom, 1988). In livestock farming, mortality can be confounded with culling, so different criteria for culling influence the incidence of mortality. Depending on the condition, some animals with signs of disease will die suddenly on the farm, others will be euthanized, some will be sent to slaughter and others will remain in the herd (Jensen et al., 2010). Culling is the selection (often on the basis of inferior quality or performance) and subsequent removal or killing of surplus animals from an animal population. The decision to cull an animal depends on many factors:

• animal factors, such as age, production, health status and reproductive performance; or
• economic factors, such as product price, the price of culled animals, and the price and availability of replacement animals (Bascom and Young, 1998).

Economic and production influences on the timing of culling of animals with disease can affect the risk of suffering (Langford and Stott, 2012). Ideally, mortality and culling rate should be low, as this would indicate that the animals were healthy and productive. However, in situations where the animals experience health problems associated with suffering, humane on-site euthanasia is an option consistent with good welfare (Morrow et al., 2006).

Many diseases with a known cause can be diagnosed precisely by clinical signs, laboratory tests and other clinical procedures. The reliability of measurements of disease is dependent on factors such as the clinical skill of the observer, the validity of the diagnostic procedures undertaken and the accuracy and consistency of records. As part of a brief welfare assessment, it might be possible to make some general observations of the animals for signs of ill health, and more detailed studies can describe the severity of clinical signs or lesions by defining categories according to specified criteria. For example, in dairy cattle, coughing, coat...
condition (hair loss, dullness), skin condition, swellings, ulceration, claw condition, body condition and locomotion scores have been used (Whay et al., 2003). The physiological effects of disease can be measured, and the severity of clinical signs can be scored by reference to photographs and by written description. For example, see Poulsen and McGuirk (2009) in relation to respiratory disease in cattle and Angell et al. (2015) for contagious ovine digital dermatitis. In addition, inspection of records for the following is beneficial in obtaining an impression of current and past health problems on a unit: treatment of clinical conditions; drugs used (bottles and containers, sale receipts and medicine records, Scott et al., 2007); dystocia; sudden death; casualty slaughter; and culling and pathology identified post-mortem at the slaughterhouse (Main et al., 2001; Whay, 2007; Leruste et al., 2012; Knage-Rasmussen et al., 2015). For example, in culled sows, common lesions found at the slaughterhouse were abscesses at various sites and skin surface injuries from bite wounds or trauma. Some sows were identified with chronic arthritis, decubital ulcers, healed fractures and osteomyelitis (Cleveland-Nielsen et al., 2004). Although there are many other factors that can affect production and fertility, examination of these records might also provide evidence of the potential effects of disease on productivity (Smith, 1998; Edwards, 2007; De Vries et al., 2011).

### Appendix 8.6 Disease Recognition

Within the EU, livestock farmers have to manage their animals by conforming to detailed legal requirements (European Council, 1998). Animals must be cared for by a sufficient number of staff who possess the appropriate ability, knowledge and professional competence. Coleman and Hemsworth (2014) reviewed the factors affecting the performance of stockpeople.

All animals kept in husbandry systems in which their welfare depends on frequent human attention should be inspected at least once a day. Animals in other systems, such as sheep in extensive systems, should be inspected at intervals sufficient to avoid any suffering. Adequate lighting is necessary so that the animals can be thoroughly inspected at any time. All stock-keepers should be familiar with normal behaviour and should watch for any signs of distress or disease. To do this, it is important that stock-keepers have enough time: to inspect the stock; to check equipment; and to take action to deal with any problem. The stock-keeper should be aware of the signs of ill health in the relevant species. Examples of signs of ill health are shown in Table 8.4.

#### Table 8.4. Examples of signs of ill health.

<table>
<thead>
<tr>
<th>Condition</th>
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<tbody>
<tr>
<td>Listlessness</td>
</tr>
<tr>
<td>Separation from the group</td>
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<tr>
<td>Unusual behaviour (Fig. 8.27E)</td>
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<tr>
<td>Lack of co-ordination</td>
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<tr>
<td>Loss of body condition</td>
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<tr>
<td>Loss of appetite</td>
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<tr>
<td>Change in water consumption</td>
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<tr>
<td>Sudden fall in production, such as milk yield or egg production or quality</td>
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<tr>
<td>Constipation or diarrhoea (Fig. 8.28E)</td>
</tr>
<tr>
<td>Discharge from the nostrils (Fig. 8.29E) or eyes</td>
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<tr>
<td>Excessive saliva</td>
</tr>
<tr>
<td>Lack of rumination</td>
</tr>
<tr>
<td>Vomiting</td>
</tr>
<tr>
<td>Persistent coughing or sneezing</td>
</tr>
<tr>
<td>Rapid or irregular breathing</td>
</tr>
<tr>
<td>Abnormal resting behaviour</td>
</tr>
<tr>
<td>Difficulty moving (assessed using a locomotion score) or lameness</td>
</tr>
<tr>
<td>Swollen joints or navel</td>
</tr>
<tr>
<td>Mastitis</td>
</tr>
<tr>
<td>Visible wounds, abscesses or injuries</td>
</tr>
<tr>
<td>Scratching or rubbing</td>
</tr>
<tr>
<td>Shivering</td>
</tr>
<tr>
<td>Discoloration or blistering of the skin</td>
</tr>
</tbody>
</table>

![Fig. 8.27E. Sick sheep showing signs associated with pneumonia.](http://www.cabi.org/openresources/90202)
Sensors can now be used for electronic identification and data collection to monitor the health of individual and groups of animals (Rutten et al., 2013; Theurer et al., 2013). Sensors located on or in animals can be used to monitor a range of variables, including location, behaviour, locomotion, body temperature (Timsit et al., 2011) and rumen acidity (Falk et al., 2016). This information can then be transmitted and interpreted by software to recognize signs of disease. Groups of animals can be monitored for sound to indicate signs of disease such as coughing, and visual analysis can be used to assess the distribution of flocks of chickens to indicate abnormal behaviour (Berckmans, 2014). Thermography could be used to detect animals with fever (Schaefer et al., 2012). Milk can be monitored for indicators of mastitis, such as changes in yield (Huybrechts et al., 2014), electrical conductivity and somatic cell count (Kamphuis et al., 2016), and also potentially for hyperketonaemia (Denis-Robichaud et al., 2015) and rumen acidity (Falk et al., 2016). Lameness can be identified using accelerometers and pressure-sensitive platforms (Schlageter-Tello et al., 2014). Individual feed intake, proximity to a feeder (Wolfiger et al., 2015) and live weight can be monitored. However, for disease identification, automatic sensors should be used to supplement rather than to replace inspection by stockpeople.


Anderson, J., Baron, M., Cameron, A., Kock, R., Jones, B. et al. (2011) Rinderpest eradicated; what next? Veterinary Record 169, 10–11. http://dx.doi.org/10.1136/vr.d4011


Appendix


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Appendix


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