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Zoonotic diseases in South American camelids in England and Wales

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SUMMARY

The number of South American camelids (SACs) in England and Wales is increasing and with this comes a risk of new and emerging infections. Although classified as livestock, these animals are also treated as pets and may be in regular contact with humans. This paper reviews zoonotic diseases that have been identified in SACs in England and Wales, and which pose a potential risk to human health. We also highlight the importance of surveillance continuing to capture information on infections in SACs for the protection of both public and animal health.

Key words: Epidemiology, zoonoses.

INTRODUCTION

There are four species of South American camelids (SACs): llama (*Lama glama*) and alpaca (*Vicugna pacos*), which are domesticated, and guanaco (*L. guanicoe*) and vicuña (*V. vicugna*), which are wild species and are uncommon in the UK.

There is no official record of SAC population numbers in the UK. In the early 1990s, a survey of UK camelid breeders recorded a population of 462, 583 and 689 camelids in the years 1990, 1991 and 1992, respectively [1], although this was likely to have been an underestimate due to the sampling methodology used. Since then, the population of SACs in the UK has grown rapidly. Data from the British Alpaca Society indicate that there are now about 35 000 alpacas and 4000 llamas in the UK [2, 3].

The majority of SACs are kept for breeding and fine wool production, while some are kept as pets, for guarding livestock, or for recreational purposes such as on open farms, in zoological collections, or for trekking. In England and Wales there is also a small, but developing, market for SAC meat products [4].

Zoonotic infections can potentially be acquired from SACs via direct or indirect contact with the animals and their environment, or via the foodborne route. A review of zoonotic infections associated with camelids is timely given the size of the industry and the recent interest in using these animals as a source of meat. Since 2000, the network of Animal and Plant Health Agency (APHA) (formerly Animal Health and Veterinary Laboratories Agency)

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Investigation Centres in England and Wales has received an increased number of samples from SACs for disease investigation which may reflect the growing popularity of these animals [5]. Disease diagnoses in England and Wales are determined from samples submitted to the APHA using its examination protocols and strict diagnostic criteria, and are recorded in its Veterinary Investigation Diagnosis Analysis (VIDA) database. This review will consider zoonotic infections that have been identified in SACs within England and Wales, examining routine data between 2000 and 2015, inclusive, and supplements the zoonotic diseases listed in a previous review of laboratory submissions from SACs in England and Wales for the years 2000–2011 [5].

Known zoonotic diseases found in SACs in England and Wales

Of the potential zoonoses which have been identified in SACs in England and Wales, tuberculosis (TB), cryptosporidiosis and sarcoptic mange are known to have been transmitted to humans [6–8]. In addition there have been putative associations between SACs and human infections of verocytotoxigenic *Escherichia coli* (VTEC) [9].

TB

The majority of TB cases identified in SACs in England and Wales are due to *Mycobacterium bovis,* however *M. microti* has also been described [10]. Both *M. bovis* and *M. microti* can cause illness in humans that is virtually indistinguishable from that caused by *M. tuberculosis*. Symptoms in humans may include a fever, persistent cough, blood in sputum and weight loss.

M. bovis is most commonly transmitted to humans by aerosol, but can also be acquired through the consumption of unpasteurized milk products [11]. The European Food Safety Authority consider the risk of acquiring infection through meat from infected animals to be negligible [11]; however, controls in SACs may not be as robust as controls for beef where there is an expectation that herds will be regularly tested for TB. Human cases of confirmed *M. bovis* infection usually represent <1% of all culture-positive human TB cases in England and Wales [12]. *M. microti* infection is even more uncommon in humans and only 25 human cases have been reported worldwide in the published literature [13–15].

In SACs, clinical signs of TB may include weight loss, inappetence, exercise intolerance and an intermittent cough. In some animals there is a short period of illness terminating with respiratory signs. Others occur as sudden deaths [10]. Most cases of TB in SACs are detected following a diagnostic post-mortem examination. Although infection can be suspected on the basis of clinical disease, tuberculin testing or serological testing, none of these is completely reliable in identifying individual TB cases [10].

Under the Tuberculosis (Deer and Camelid) (England) Order 2014 (and similar orders made by the devolved governments), the suspicion of TB in the carcase of a farmed or pet mammal is notifiable to APHA. Since the introduction of these Orders, there has been an increase in the number of samples/carcases received by APHA for examination and TB culture [10].

M. bovis

Between 2000 and 2015, bacteriologically confirmed *M. bovis* infection was reported in 98 camelid herds in England and Wales [16]. Nearly all of those cases occurred in areas where TB is endemic in cattle and badgers, and it is possible that cases in SACs reflect infection spillover from those true reservoir species. There is also some evidence from field epidemiological investigations undertaken by APHA to suggest that TB can additionally spread between SAC premises through the movement of undetected infected camelids [17, 18].

There have been two documented cases of human *M. bovis* infection attributed to close and/or prolonged contact with tuberculous camelids in England. The first involved a veterinary surgeon in Devon who developed a cutaneous granuloma in her thumb a few weeks after treating, euthanazing and conducting a post-mortem examination on an infected alpaca with extensive TB pathology in the thorax [7]. The second incident occurred in an alpaca owner who was diagnosed with pulmonary TB after the disease was also diagnosed in her own alpaca herd (PHE, unpublished data).

M. microti

M. microti infection occurs sporadically in SACs in England and Wales [10]. Of the 25 human cases of *M. microti* recorded worldwide in the published literature, nine were of the spoligotype previously isolated from llamas (although this does not necessarily

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indicate that llamas are a reservoir host). Only one of the cases (a 44-year -old woman from Scotland) was known to have had a possible connection to SACs. However, a causal association between the alpaca and patient was not confirmed and other possible sources of infection were noted [13].

Cryptosporidiosis

Cryptosporidiosis is a common enteric infection of humans and animals. Human infection with *Cryptosporidium* spp. occurs through direct contact with the faeces of an infected human or animal, through consumption of food or water that has become contaminated by faeces from infected animals, or through indirect contact with contaminated environments or contaminated water. The main zoonotic species is *C. parvum*, which has a large range and abundance of animal reservoirs and is particularly common in young farmed animals [19].

Cryptosporidiosis is a recognized, although uncommonly reported, cause of diarrhoea in SACs in England and Wales. Between 2000 and 2015, there were 26 diagnoses of cryptosporidiosis in SACs from material submitted to APHA for diagnostic investigation. In samples submitted from diarrhoeic alpaca and llama crias (young camelids) in England and Wales between 1999 and 2005, a prevalence of cryptosporidiosis of 8·8% was reported [20]. However, clinical data from cases seen at The Ohio State University found a prevalence of 26% in crias presenting with diarrhoea [21]. *Cryptosporidium* infection was diagnosed as the cause of death of three alpaca cria on a holding in England in 1998 [22], and was also diagnosed in two outbreaks of disease on English alpaca holdings in 2005–2006 [20]. Additionally, *C. parvum* was associated with the death of three 8-month-old weaned alpacas in England in 2012 [23].

There are no documented reports of zoonotic transmission of *C. parvum* from alpacas to humans in England and Wales, but in the United States an outbreak of cryptosporidiosis in alpaca crias was putatively associated with *Cryptosporidium* infection in people involved in their care. Three people were confirmed to have cryptosporidiosis and three others were suspected cases. One of the confirmed human cases was associated with contact with an apparently healthy cria [6]. When evaluating the zoonotic risk of *Cryptosporidium* infection in SACs, it is therefore important to consider the potential for both healthy and diseased animals to excrete oocysts which may act as a source of infection for humans.

Sarcoptic mange

Sarcoptes is one of the most frequently diagnosed ectoparasites in SACs in England and Wales. Infection with this parasite has been reported in alpacas in the UK [24, 25], and 35 cases were diagnosed at APHA Investigation Centres between 2000 and 2015. Sarcoptic mange is zoonotic and can cause an intensely itchy rash in humans.

In SACs, *Sarcoptes* infections usually present with pruritus, alopecia, thickened skin, crust formation, erythema and excessive scaling. In severe cases, death may result [25]. There are historical accounts of large epidemics affecting camelids in South America with mortalities of over 50%, although it is not clear if other diseases were considered as differential diagnoses [8]. In 2007, mange was reported in 151/292 (52·2%) alpaca herds and 9/66 (14%) llama herds in the UK whose owners responded to a questionnaire (although about half of these were not confirmed by a veterinarian or animal health laboratory) [26].

There has been a small number of reports of accidental and experimental human infection associated with SAC contact [8, 27], and natural concomitant infections in SACs and their owners/keepers have also been reported [25, 28]. This may reflect the regularity with which owners are likely to handle their animals, particularly when showing, moving, grooming and bathing, which may facilitate exposure. Treating affected animals may also carry a risk of exposure.

VTEC

When considering zoonotic potential, the most important strains of *E. coli* are those which produce toxins, including VTEC O157. Symptoms of VTEC infection in humans can range from asymptomatic infection or mild gastroenteritis to severe bloody diarrhoea, mostly without fever. Infection is also associated with two serious syndromes, haemolytic uraemic syndrome, and thrombotic thrombocytopaenic purpura, that affect the blood, kidneys and, in severe cases, the central nervous system.

VTEC O157 is commonly found in the intestines of animals including SACs, but has rarely been associated with clinical disease in animals. VTEC O157 is shed in faeces and saliva. Zoonotic transmission occurs via the faecal–oral route, with humans

becoming infected through the consumption of contaminated food, through contact with infected people, or through contact with infected animals or their environment.

A review of VTEC O157 in animals on open farms in England and Wales which had putative associations with human cases of VTEC infection identified an apparent high carriage rate of VTEC O157 in SACs [9]. A 2009 opportunistic survey of SAC carcases submitted to APHA Investigation Centres for diagnostic post-mortem examination, and faecal samples submitted for routine monitoring or diagnostic purposes, found that 3/188 (1·6%) samples tested from 96 premises were positive for VTEC O157. The three positive samples were all obtained from adult alpacas from a single premise. This level of infection is similar to that found in other farmed species [29].

Other potentially zoonotic diseases found in SACs in England and Wales

A number of other potentially zoonotic pathogens are known to infect SACs in England and Wales, but to date there are no confirmed documented cases of transmission between SACs and humans anywhere in the world:

- *Campylobacter* spp. are a major cause of acute bacterial enteritis in humans worldwide. The majority of infections are caused by *C. jejuni* and *C. coli*, and there is considerable variation in the severity of illness, ranging from asymptomatic to severe abdominal pain and diarrhoea. Other *Campylobacter* species may also have zoonotic potential, but human infection is comparatively rare. *C. fetus* subsp. *fetus* is a very rare cause of severe systemic infection in humans, and can also cause abortions in animals. In 2009, *C. fetus* subsp. *fetus* was isolated from fetal stomach contents and placenta, as well as from a sample of faeces from an adult alpaca, on a farm in England where there had been four abortions and one premature, non-viable cria, in the alpaca herd [30].
- Dermatophytosis (ringworm; i.e. *Trichophyton* spp. or *Microsporum* spp. infection) is an infection that normally causes mild skin disease in humans and can cause alopecia in SACs. Five cases in SACs were reported to the APHA between 2000 and 2015.
- Erysipeloid is a rare skin condition in humans caused by the bacterium *Erysipelothrix rhusiopathiae*. In people, the most common presentation is a bacteraemia or localized cellulitis, although systemic disease such as meningitis can also occur. In animals, infection is most commonly seen in sheep and pigs. In sheep, the disease usually presents as polyarthritis, while in pigs the clinical manifestations include urticaria, septicaemia, polyarthritis, pneumonia, abortion and death. Between 2000 and 2015, *Erysipelothrix* sp. was isolated only once in SACs, from an adult alpaca with endocarditis.
- Leptospirosis in humans causes a spectrum of illness from asymptomatic or mild, self-limiting, influenza-like illness, through to severe and fatal hepto-renal failure. Leptospirosis is a global cause of animal disease and economic loss, with clinical variations according to serovar and animal species involved. Rodents, livestock and domestic mammals such as cattle, pigs and dogs serve as major reservoir hosts for leptospires. Infection in alpacas has been confirmed in England and Wales, with the demonstration of pathogenic leptospiral DNA by PCR assay in the kidney from an aborted alpaca fetus [5, 31].
- Listeriosis, caused by infection with *Listeria monocytogenes*, is a rare but potentially life-threatening disease in humans with more serious consequences likely to occur in elderly people, immunosuppressed patients or pregnant women. Most human infections are considered to be foodborne in origin; however, other routes of transmission can occur. In animals, listeriosis usually presents as encephalitis, abortion, septicaemia or enteritis. Examination of VIDA data confirms there have been 15 cases of listerial infection in SACs in England and Wales between 2000 and 2015. The cases, which included confirmed isolations of *L. monocytogenes*, presented as either the nervous system or septicaemic forms of the disease.
- Louping ill is a tickborne viral disease which can cause fever and/or potentially serious infections of the brain or spinal cord in humans. In animals it may also cause pyrexia, neurological disease and death. There were two cases of louping ill in SACs in England between 2000 and 2015 [5, 32].
- *Salmonella* infection in humans can cause watery diarrhoea, stomach cramps and sometimes vomiting and fever, while clinical signs in animals include pyrexia, lethargy, diarrhoea and abortion. Twenty-three cases of *Salmonella* infection (including two abortions: one caused by *S.* Dublin and one by *S.* Typhimurium) have been confirmed in SACs by APHA between 2000 and 2015. The following serovars were reported: Typhimurium (including 4,5,12: i:-) ($n = 11$), Anatum ($n = 3$), Dublin ($n = 3$),

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Newport ($n = 3$), Agama ($n = 1$), Bovismorbificans ($n = 1$) and Oslo ($n = 1$).

- Bacteria of the *Streptococcus bovis*/*S. equinus* complex (SBSEC) are associated with underlying gastrointestinal malignancy and cause bacteraemia and meningitis in humans, while in animals they are considered to be opportunistic pathogens and can cause septicaemia and meningitis. Examination of VIDA data revealed five cases in SACs, diagnosed between 2000 and 2015, including one fatal case of infection with *S. bovis* biotype I (as named prior to the updated nomenclature) in an alpaca cria with an unknown source of infection [33].
- *S. equi* subsp. *zooepidemicus* may cause pneumonia, meningitis, endocarditis and septic arthritis in humans. In SACs, it causes polyserositis and septicaemia, with high mortality, and is known as 'alpaca fever' [34]. Examination of VIDA data reveals seven cases diagnosed in alpacas from samples submitted to APHA between 2000 and 2015.
- *S. suis* is a rare zoonotic pathogen of humans, which can cause meningitis and septicaemia, particularly in immunocompromised people. In animals, infection is mostly seen in pigs although it is also occasionally detected in other species. Between 2000 and 2015, examination of VIDA data revealed a single case of *S. suis* infection in SACs, isolated from the joint fluid of a 5-month-old lame alpaca.
- *Trombicula* spp. harvest mites (also known as 'chiggers') can be associated with pruritic dermatitis in humans and is believed to be transmissible to humans from direct contact with an infested animal (e.g. from cats and dogs). In camelids, the mites cause pruritus, crusting and alopecia. In England and Wales there was one small outbreak of *Trombicula* spp. in SACs in 2008 [35].
- Yersiniosis in humans can cause diarrhoea, abdominal pain, fever and arthritis. Infections in animals are generally asymptomatic, although they can also be associated with diarrhoea and abortion. Examination of VIDA data for 2000 to 2015 identified 15 cases of disease in SACs. Speciation of the *Yersinia* isolate was not always provided; however, one abortion was caused by *Y. enterocolitica*.

Zoonotic diseases found in SACs outside England and Wales

In addition to the diseases discussed above, there are zoonotic infections which have caused SAC disease in other countries, but not yet in England and Wales. For example, in 2009 cowpox virus (CPXV) was isolated from the skin lesions of a llama on a farm in Italy [36]. CPXV causes human cowpox, a rare zoonotic infection which can be severe in immunocompromised patients, particularly children. Human cowpox does occur sporadically in the UK, most often acquired from cats, and SACs in England and Wales are at potential risk of acquiring CPXV from indigenous wild rodents or farm cats.

Other particularly important examples of zoonotic diseases that affect camelids elsewhere in the world include rabies and brucellosis [37–39].

Additionally, the risk of importing diseases to England and Wales should not be overlooked. A survey in 2000/2001 of 218 camelid owners indicated that almost 45% had at least one animal that had been imported from South America [40].

DISCUSSION

Over the past 20 years, SACs have become an established species in England and Wales, and with this comes a risk of new and emerging infections. Although classified as livestock, the animals are often treated as pets and are sometimes reported to be hardy and relatively disease-resistant. This is not entirely accurate; in the UK, SACs are good sentinels for disease since they are susceptible to some of the diseases seen in cattle and sheep [5].

SACs may have regular and close human contact. Understanding the diseases associated with these animals and the possible risks to human health is important for those who keep and breed SACs, for members of the public who may encounter them at petting farms or during other recreational activities, and for veterinary professionals who come in contact with live animals and pathological specimens. It is also important for medical professionals and other public health workers to be aware of the risks in order to help inform human disease investigations.

While many different pathogens have been associated with disease in SACs worldwide, this paper has focussed mainly on diseases that infect SACs in England and Wales and are a direct risk to human health. In addition, there are a number of potentially zoonotic diseases that may pose an indirect risk via, for example, environmental contamination, such as fascioliasis.

The number of case reports of SAC-associated disease in humans is relatively small compared to

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diseases associated with other animals, but nonetheless it is important to consider suitable control measures. For example, it is equally important to apply risk mitigation strategies designed to control the risk of VTEC O157 infection for visitors to alpacas and llamas on open farms as it is to cattle and sheep. Furthermore, given the association of abortions with four zoonotic pathogens (*C. fetus* subsp. *fetus*, *Leptospira* spp., *Salmonella* spp., *Yersinia* spp.), standard public health advice for people handling products of conception, especially pregnant women, should apply to SACs as well as to other farmed livestock [41].

This paper highlights how disease surveillance systems for newly established animal populations can identify diseases of zoonotic importance. As the surveillance is often passive, the figures cited in this paper are likely to under-represent the true burden of infection. It is important that surveillance continues to capture information on infections in SACs for the protection of both public and animal health.

DECLARATION OF INTEREST

None.

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