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INFECTIOUS DISEASE

Severe Foot Lesions in Dairy Goats Associated with Digital Dermatitis Treponemes

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Summary

Treponeme-associated foot disease has been described in cattle with digital dermatitis and sheep with contagious ovine digital dermatitis. In this study, severe foot lesions in dairy goats associated with digital dermatitis treponemes (i.e. *Treponema medium*, *Treponema phagedenis* and *Treponema pedis*) were characterized macroscopically, radiographically and histologically. The main macroscopic foot lesion was of extensive solar ulceration with or without exophytic papilliform hyperkeratosis. Radiographically, the distal phalanx and distal sesamoid bones were severely damaged and remodelled. Histologically, the lesion was categorized as a chronic lymphoplasmacytic, suppurative and ulcerative pododermatitis. Immunohistochemistry identified the spirochaetal microorganisms located extracellularly in the superficial horn. Study limitations mean that the treponeme bacteria could not be considered the sole or causal agents in the cases described.

Keywords: digital dermatitis; goat; treponeme

Introduction

Lameness in domesticated ruminants is widely recognized as an important animal welfare (Whay *et al.*, 1997; Angell *et al.*, 2015a) and economic problem (Reader *et al.*, 2011). In the UK, lameness in dairy goats has been identified as a common welfare problem (Anzuino *et al.*, 2010); however, the diseases causing lameness are less well described than in cattle (Weaver, 1972; Sibley, 2013) and sheep (Winter, 2011). Generally, goat lameness problems are described as similar to those found in sheep (Winter, 2011). However, interdigital dermatitis (Zhou *et al.*, 2009; Sullivan *et al.*, 2015a), foot rot (Piriz Duran et al., 1990), heel horn erosion (Christodoulopoulos, 2009), white line disease, foreign body penetrations (Mgasa and Arnbjerg, 1993) and overgrown feet (Anzuino *et al.*, 2010) have all been recorded in goats. Most recently, two research groups in the UK have reported a severe foot disease in dairy goat herds associated with *Treponema* spp. commonly detected in infectious foot lesions in farm animals (Groenevelt *et al.*, 2015; Sullivan *et al.*, 2015b).

These treponeme-associated foot diseases occur in several animal species. In each case, they have been associated with three cultivable digital dermatitis (DD) treponeme phylogroups: *Treponema medium*, *Treponema phagedenis* and *Treponema pedis*. These diseases include DD in dairy and beef cattle (Evans *et al.*, 2009), a disease of global distribution;

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contagious ovine digital dermatitis (CODD) in sheep in the UK (Dhawi *et al.*, 2005; Duncan *et al.*, 2014) and Ireland (Sayers *et al.*, 2009); foot lesions in wild elk (*Cervus elaphus*) in the USA (Clegg *et al.*, 2015) and equine canker (Sykora and Brandt, 2015). These treponeme-associated hoof lesions are markedly different between species in terms of their gross pathological appearance, even though detection and isolation of the same treponeme phylogroups occurs consistently. While interspecies transmission of *Treponema* spp. has not yet been demonstrated, it may be theoretically possible given the similarity of the infectious organisms.

In cattle, the three DD treponemes are considered to be the primary aetiological agents of DD (Evans *et al.*, 2009) and are hypothesized to be the primary infectious cause of CODD (Sullivan *et al.*, 2015a). However, in cattle, secondary infection of pre-existing claw horn defects with the DD treponeme bacteria also occurs, resulting in severe non-healing foot lesions (Evans *et al.*, 2011). In goats, it is unknown whether the treponeme-associated foot disease is a primary bacterial disease or represents secondary invasion of claw horn defects, as is seen in the non-healing cattle foot lesions.

The gross and histopathological aspects of goat treponeme-associated foot disease have not been formally described. Such data would help inform understanding of the disease process in this species, and consequently would inform disease control measures. The published clinical presentations of the disease are varied with no single distinct clinical pattern. Groenevelt *et al.* (2015) reported that the majority of cases had involvement of the sole to some extent. Sullivan *et al.* (2015b) observed some lesions, which included the coronary band and hoof wall, while other lesions had more solar horn involvement. The aim of the present study was to investigate further the disease process of treponeme-associated foot disease in goats by characterizing the clinical, radiographical and histopathological features of the disease in a UK dairy goat herd.

Materials and Methods

Farm Background

All observations and samples of diseased feet were collected from a single UK dairy goat farm with a recent history of treponeme-associated foot disease (Sullivan *et al.*, 2015b). The farm consisted of 856 milking goats of various breeds. The goats were housed all year round in four straw yards (approximately 250 goats per yard) and house and milking parlour hygiene was assessed subjectively as extremely good by two of the authors. The goats were milked twice daily and fed on a total mixed ration including silage and cereal. Foot care included twice weekly foot bathing on exit from the parlour in 10% zinc sulphate and regular preventive and therapeutic foot trimming (every 3 months). For those goats with foot lesions, topical treatment with Derm Paste™ (Hoofcare Supplies, Selby, UK) and systemic antibiotics were used as prescribed by the farmer's usual veterinary surgeon.

Ethical approval for this study was obtained from the University of Liverpool Veterinary School Ethics Committee.

Animal Sampling

Data from the study farm were collected on two separate occasions in 2014 and 2015 (6 months apart). All animal sampling was with owner's consent and therefore limited by the discretion of the farmer. At the first visit, seven lame goats identified for culling by the farmer were humanely destroyed. After death, the fore- and hindlimbs of these goats were removed by disarticulation at the carpal and the tarsal joints, respectively. The foot lesions were photographed and samples of tissue were collected and placed in 10% neutral buffered formalin within 30 min of death. Tissue samples taken from the coronary band region were frozen at −20°C for microbiological examinations (polymerase chain reaction [PCR] and culture). The formalin fixed feet underwent subsequent clinical, radiographical, histopathological and immunohistochemical investigations.

On the second visit, a whole herd lameness assessment was carried out and 10 lame goats were examined; their foot lesions described, photographed and swabbed for microbiological assessment.

Control material was obtained from goats from a fallen stock centre with no macroscopic foot lesions. One goat was used as a control for radiography while three control goats, provided 12 'healthy' control tissue samples for PCR.

Herd Lameness Score

The gait of all milking goats was observed (by HC-D) as the goats exited the milking parlour. Due to the number of goats and their speed on exiting the parlour, a simple binary scoring system of lame/not lame was used (Phythian *et al.*, 2013).

Clinical Foot Lesion Descriptions

All foot lesions were photographed and the lesions categorized based on the foot lesion descriptors from the International Committee for Animal Recording