

Update on contagious ovine digital dermatitis

*Jennifer Duncan BVM&S BSc. (Hons) PhD Dip. ECSRHM MRCVS^a

Dai Grove-White BVSc MSc Dip. LSHTM DBR PhD Dip. ECBHM FRCVS^a

Joseph Angell BVSc MSc Dip. LSHTM PhD MRCVS^b

^a Department of Livestock Health and Welfare, Institute of Veterinary Science, The University of Liverpool, Leahurst Campus, Neston, Wirral, CH64 7TE, UK

^b Department of Epidemiology and Population Health, Institute of Infection and Global Health The University of Liverpool, Leahurst Campus, Neston, Wirral, CH64 7TE, UK

*Corresponding author. Tel.: +44 151 7946050; Fax: +44 151 7946034; E-mail address: jsduncan@liv.ac.uk

Introduction

Contagious ovine digital dermatitis (CODD) is an emerging disease of sheep first reported in the UK in 1997. Since then it has become widespread in the national flock with an estimated 50% of sheep farms affected. There are also several unconfirmed reports of the disease occurring in other parts of the world (personal communication, JW Angell). Clinically, it presents as an initial proliferative or ulcerative lesion at the coronary band, progressing to separation and eventual avulsion of the hoof capsule (figures 1 and 2). The disease causes severe lameness in sheep and can be difficult to manage. Until recently, there was only a small evidence base for vets and farmers to utilise in the control of CODD. This article summarises significant, recent advances in our understanding of CODD and advises on treatment and prevention strategies for the disease.

Aetiology

Over the years, many different bacteria have been isolated by culture and indicated by PCR from individual CODD lesions. These include *Dichelobacter nodosus*, *Fusobacterium necrophorum* and three members of the treponema genus namely *Treponema medium*-like, *Treponema phagedenis*-like and *Treponema pedis* [the digital dermatitis (DD) Treponemes]. Recent research has strongly supported the involvement of the DD Treponemes in CODD lesions. Microbiological studies of 58 CODD feet found at least one of these three DD treponemes in 100% of CODD lesions examined, whilst no DD treponemes were isolated from healthy feet (Sullivan and others 2015). Furthermore, immunohistochemistry of CODD lesions (Angell and others 2015d) identified large numbers of these organisms in both early grade lesions and later more advanced CODD lesions and were specifically associated with the pathological changes to the foot. Studies of CODD feet and healthy feet identified *Dichelobacter nodosus* and *Fusobacterium necrophorum* in 59% and 71% of CODD lesions and 39% and 9% of healthy foot tissues, respectively. *Dichelobacter nodosus* is believed to be the causative agent of footrot in sheep. However, frequent isolation from CODD lesions and evidence from several epidemiological studies, suggests an important association between footrot and CODD.

Currently, the precise aetiology and role of the different consortia of bacteria identified in CODD lesions is unclear, however the DD treponemes are emerging as a necessary cause of disease.

Research work presently underway should provide more definitive answers as to the aetio-pathogenesis of the disease in the near future.

Microbiologically, CODD would appear to share much in common with both bovine digital dermatitis (BDD) and a severe treponeme associated foot disease in goats (Sullivan and others 2014b) (see Box 1) and wild American elk. The treponeme bacteria isolated from these lesions are very similar. Full genome sequencing is required to determine if they are in fact the same treponeme bacteria present in the foot lesions of these different animal species. Furthermore, the clinical presentations of these three treponeme associated diseases are very different; with severe horn disruption in cases with CODD, contrasting markedly with the discrete cutaneous lesions observed in typical BDD. Currently it is still unknown if and how disease may transmit between species.

Establishing the transmission routes for the DD treponemes has challenged researchers for many years. Answers are beginning to emerge, largely due to the application of novel molecular techniques such as targeted deep sequencing. Digital dermatitis associated treponemes have now been detected in the dairy herd environment in fresh faeces and slurry from cattle (Klitgaard and others 2014) and on sheep and cattle hoof trimming equipment (Sullivan and others 2014a). These findings suggest potential routes of transmission of DD treponeme bacteria and emphasise the importance of between animal, between farm and on-farm hygiene practices.

Box 1: Treponeme Associated Foot Disease in Dairy Goats in the UK.

In 2014 veterinary researchers reported a new severe foot disease in housed dairy goat herds in the UK. The digital dermatitis treponemes, *Treponema medium*-like, *Treponema phagedenis*-like and *Treponema pedis* were isolated from all clinical cases, although it is not certain that the treponeme bacteria are the only cause of the disease in goats. There is not one single description of the disease presentation yet, however a common finding appears to be extensive toe, wall or sole ulcers (figures 3 and 4).

The disease can cause a severe lameness and seems to spread between goats and herd prevalence can be high. The mechanism of disease spread is unknown; however, in the authors' opinion and given recent research work on DD treponemes and hoof trimming equipment, the following advice may be helpful in controlling infection herds.

- review foot trimming practices, consider whether foot trimming is necessary:- take extra care with routine hoof trimming of over- grown feet. **Never** over trim feet and **never** cause bleeding
- clean and disinfect hoof clippers and gloves between goats and the handling area after a trimming session
- isolate affected goats
- Use veterinary prescribed treatment for affected goats
- improve underfoot hygiene, keep bedding and walking surfaces as **clean and dry** as possible, especially in the collecting yard

Clinical Presentation of CODD

Currently a diagnosis of CODD is based on clinical signs and it is not unusual for CODD to be confused with other foot diseases of sheep. There are different clinical grades of CODD lesions and certainly in advanced cases, differentiation of different foot diseases can be difficult even for the most experienced eye. In addition, multiple foot diseases are often present on a farm simultaneously. For

these reasons, when investigating lameness problems on a farm it is essential to examine as many lame sheep as possible to determine which diseases are present. Differential diagnoses for CODD lesions in sheep include:-

- Foot abscess
- Footrot
- Interdigital Dermatitis (scald)
- White Line Disease
- Foot Granuloma
- Strawberry Footrot

Research (Angell and others 2015b) has led to the development of a five point grading scheme for CODD to inform on farm diagnosis (see Box 2). In the authors' experience common confusions occur between foot abscesses discharging at the coronary band and CODD grades 1 and 2; advanced footrot and CODD grade 3; foot granulomas and CODD grade 4.

A practical on farm locomotion scoring tool is now available for sheep (Angell and others 2015c) Box 3 which can be used to aid assessment of lameness problems in a flock, and the prompt identification and treatment of lame sheep by farmers. It is vital to recognise that lameness levels vary throughout the year and figures should only be seen as a general guide to flock level lameness. Application of this tool in CODD studies has identified a number of important aspects of the disease with implications for control. Firstly, not all sheep with CODD are lame and therefore relying on lameness identification for example, as a biosecurity measure to prevent introduction of CODD, will not prevent disease introduction. Secondly, of all foot diseases observed, CODD causes the most severe degree of lameness, and even sheep with healed lesions can still be lame. This is possibly due to pathology observed in the pedal bone in some cases (figure 10) or other neuropathic mechanisms. These findings emphasise the severity of CODD as a welfare issue for sheep.

The amount of disease on farms will vary considerably from farm to farm and throughout the year. Typically farmers report disease prevalence to be around 2% but levels of up to 50% of sheep affected have been recorded. Epidemiological studies have identified a number of risk factors associated with disease prevalence and which have important implications for CODD control (see later). The most significant of these was the presence of footrot, large flock size, sheep grazing on lowland pasture, lush pasture and poached pasture. A seasonal trend has also been observed with peaks seen in late summer/early autumn.

Box 2 CODD Lesion Grading System (Angell and others 2015a)

Figure 5: Grade 1 CODD: This is the earliest stage of lesion whereby we observe erosion/ulceration with or without hair loss specifically at the level of the dorsal coronary band.

Figure 6: Grade 2 CODD: Erosion/ulceration of the skin at the coronary band with partial (<50%) under-running of the hoof horn dorsally, abaxially and tending towards circumferential under-running.

Figure 7: Grade 3 CODD: Erosion/ulceration of the skin at the coronary band with 50% -100% under-running of the hoof horn with possible hoof horn avulsion.

Figure 8: Grade 4 CODD: Healing foot with the horn beginning to regrow but an active lesion still present.

Figure 9: Grade 5 CODD: Healed foot, often with deformation of the regrown horn.

Box 3: Locomotion Scoring Tool For Sheep (Angell and others 2015c)

0: (SOUND) Bears weight evenly on all four feet and walks with an even rhythm.

1: (MILDLY LAME) Steps are uneven but it is not clear which limb or limbs are affected.

2: (MODERATELY LAME) Steps are uneven and the stride may be shortened; the affected limb or limbs are identifiable.

3: (SEVERELY LAME) Mobility is severely compromised such that the sheep frequently stops walking or lies down due to obvious discomfort. The affected limb or limbs are clearly identifiable and may be held off the ground whilst walking or standing.

Control of CODD

A lack of controlled treatment trials has resulted in a wide range of both non-antibiotic and antibiotic strategies being used in the field to treat CODD, including parenteral injectable antibiotics and topical foot bathing. Lack of efficacy, off-license use, variability in on farm application methods, issues with disposal and responsible antibiotic use mean that topical foot bathing in antibiotic solutions are not generally recommended. The efficacy on non-antibiotic foot bathing solutions has yet to be established.

There are very few field studies examining the efficacy of parenteral antibiotic treatments for CODD. In a randomised controlled trial, a single dose of long acting amoxicillin was found to achieve a clinical cure in 71% of sheep affected by CODD (Duncan and others 2012). A combination of topical tylosin and systemic long acting oxytetracycline was found to have significant benefits in management of mixed foot infections (CODD, footrot and scald) in housed lambs (Judson 2010). Tilmicosin and tulathromycin products are licensed for use for footrot in sheep and have been used by vets for control of CODD. There is also *in vitro* and *in vivo* evidence for their efficacy in treating individual sheep CODD cases (Angell and others 2016). More work is needed to provide robust evidenced based treatment strategies for CODD. From a biosecurity perspective it is worth noting that no treatment has yet been shown to achieve a bacteriological cure.

Whole-flock treatments with macrolide antibiotics have been advocated for use in an attempt to eradicate CODD from flocks. A robust randomised controlled trial examining the efficacy of this approach using tilmicosin (Angell and others 2016) showed no significant difference for the clinical elimination of CODD (and footrot) between those flocks that used the tilmicosin intervention and the control farms that carried on with their current lameness control practices. Given these results and current serious concerns over antibiotic resistance this practice is not recommended for CODD.

As mentioned several times in this article there is epidemiological, microbiological and field data linking CODD and footrot, and certainly clinically it is very common to see both diseases on farms together. One study examined the efficacy of the footrot vaccine Footvax (MSD) in preventing CODD (32% risk reduction) and footrot (68% risk reduction) (Duncan and others 2012); highlighting the useful role of footrot vaccination in lameness control in sheep flocks. Therefore a key aspect of the control of CODD on a farm is now considered to be the control of footrot. There have been significant

advances in the management of footrot on UK farms and useful summaries have been published (AHDB 2016),(Green 2016) (Clements and Stoye 2014).

From the outcomes of research on CODD, there are three key areas of advice for the control of CODD on farms.

Box 4: From Responsible Use of Antimicrobials in Veterinary Practice (BVA 2015)

Fluoroquinolones, third/fourth generation cephalosporins and macrolides

The need for use of fluoroquinolones, third and fourth generation cephalosporins, and macrolides should always be carefully considered. We strongly discourage their use in groups or flocks of animals except in very specific situations; special attention should be given to the risk of antimicrobial resistance to these products as part of the benefit/risk assessment.

Use of these antimicrobials should be reserved for the treatment of clinical conditions that have responded poorly, or are expected to respond poorly, to other classes of antimicrobials.

Off label use should be strongly discouraged.

1. Biosecurity
 - a. Quarantine bought in sheep, and as not all sheep with CODD are lame, individually examine feet on arrival for CODD lesions. Treat (and isolate) or return sheep to the vendor (preferable) as appropriate.
 - b. Ensure high standards of personal and equipment biosecurity between farms.
2. Treatment of individual CODD cases
 - a. Isolation of affected sheep in a lame pen or lame group may facilitate treatment and reduce disease spread.
 - b. *In vitro* and *in vivo* studies have demonstrated the efficacy of systemic long acting amoxicillin and macrolide treatments for the **clinical** cure of CODD in individual sheep (repeat treatments may be required). Vets are reminded to follow current professional guidelines for responsible use of antimicrobials (BVA 2015, Box 4)
 - c. After treating individual lame sheep, clean and disinfect hands (gloves) and equipment between sheep. Although we have no direct evidence to support this, given the infectious nature of CODD, cleaning and disinfection of handling areas and lameness pens after use would seem a wise precaution.
3. Flock level control should reflect that footrot and CODD are linked so it is important to control both diseases together in an individual farm lameness control plan. For example by using tools such as prompt individual treatment, footrot vaccine, improving under foot hygiene, culling and biosecurity measures.

References

AHDB (2016) Reducing Lameness for Better Returns <http://beefandlamb.ahdb.org.uk/wp/wp-content/uploads/2016/03/BRP-Reducing-lameness-manual-7-080316.pdf>. Accessed August 2016 Access, 2016

ANGELL, J. W., BLUNDELL, R., GROVE-WHITE, D. H. & DUNCAN, J. S. (2015a) Clinical and radiographic features of contagious ovine digital dermatitis and a novel lesion grading system. *Veterinary Record* 176 page numbers missing

- ANGELL, J. W., CLEGG, S. R., SULLIVAN, L. E., DUNCAN, J. S., GROVE-WHITE, D. H., CARTER, S. D. & EVANS, N. J. (2015b) In vitro susceptibility of contagious ovine digital dermatitis associated *Treponema* spp. isolates to antimicrobial agents in the UK. *Veterinary Dermatology* 26, 484-e115
- ANGELL, J. W., CRIPPS, P. J., GROVE-WHITE, D. H. & DUNCAN, J. S. (2015c) A practical tool for locomotion scoring in sheep: reliability when used by veterinary surgeons and sheep farmers. *Veterinary Record* 176 (20), 521-523
- ANGELL, J. W., CROSBY-DURRANI, H. E., DUNCAN, J. S., CARTER, S. D. & BLUNDELL, R. (2015d) Histopathological Characterization of the Lesions of Contagious Ovine Digital Dermatitis and Immunolabelling of *Treponema*-like Organisms. *Journal of Comparative Pathology* 153, 212-226
- ANGELL, J. W., GROVE-WHITE, D. H., WILLIAMS, H. J. & DUNCAN, J. S. (2016) Whole-flock, metaphylactic tilmicosin failed to eliminate contagious ovine digital dermatitis and footrot in sheep: a cluster randomised trial. *Veterinary Record* 179 (12), 308
- BVA (2015) Responsible Use of Antimicrobials in Veterinary Practice. <https://www.bva.co.uk/News-campaigns-and-policy/Policy/Medicines/Antimicrobials/>. Accessed 25/10/2016 Access, 2015
- CLEMENTS, R. H. & STOYE, S. C. (2014) The 'Five Point Plan': a successful tool for reducing lameness in sheep. *Veterinary Record* 175 (9), 225
- DUNCAN, J. S., GROVE-WHITE, D., MOKS, E., CARROLL, D., OULTRAM, J. W., PHYTHIAN, C. J. & WILLIAMS, H. W. (2012) Impact of footrot vaccination and antibiotic therapy on footrot and contagious ovine digital dermatitis. *Veterinary Record* 170, 462
- GREEN, L. E., (2016) Footrot in Sheep
<http://www2.warwick.ac.uk/fac/sci/lifesci/research/greengroup/farmersandvets/footrotinsheep/>. Accessed August 2016
- JUDSON, D. (2010) Can CODD and footrot be eradicated with a single whole group antibiotic treatment. *Proceedings of the Sheep Veterinary Society* 34, 109-112
- KLITGAARD, K., NIELSEN, M. W., INGERSLEV, H.-C., BOYE, M. & JENSEN, T. K. (2014) Discovery of Bovine Digital Dermatitis-Associated *Treponema* spp. in the Dairy Herd Environment by a Targeted Deep-Sequencing Approach. *Applied and Environmental Microbiology* 80, 4427-4432
- SULLIVAN, L. E., BLOWEY, R. W., CARTER, S. D., DUNCAN, J. S., GROVE-WHITE, D. H., PAGE, P., IVESON, T., ANGELL, J. W. & EVANS, N. J. (2014a) Presence of digital dermatitis treponemes on cattle and sheep hoof trimming equipment. *Veterinary Record* 175 (8), 201
- SULLIVAN, L. E., CLEGG, S. R., ANGELL, J. W., NEWBROOK, K., BLOWEY, R. W., CARTER, S. D., BELL, J., DUNCAN, J. S., GROVE-WHITE, D. H., MURRAY, R. D. & EVANS, N. J. (2015) High-Level Association of Bovine Digital Dermatitis *Treponema* spp. with Contagious Ovine Digital Dermatitis Lesions and Presence of *Fusobacterium necrophorum* and *Dichelobacter nodosus*. *Journal of Clinical Microbiology* 53, 1628-1638
- SULLIVAN, L. E., EVANS, N. J., CLEGG, S. R., CARTER, S. D., HORSFIELD, J. E., GROVE-WHITE, D. & DUNCAN, J. S. (2014b) Digital dermatitis treponemes associated with a severe foot disease in dairy goats. *Veterinary Record* 176 (11), 283