BRIEF COMMUNICATIONS

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Spirochete-associated bovine digital dermatitis

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Bovine digital dermatitis was first described in the early 1970's as an ulcerative and proliferative lesion of the heel bulb or proximal interdigital space (1). It is now being reported with increasing frequency throughout Europe, the United Kingdom, and the United States. In the United Kingdom, digital dermatitis is the most common skin lesion observed in association with bovine lameness (2). Filamentous bacteria with the morphology of spirochetes have recently been associated with lesions of digital dermatitis in England (3) and in California (letter, Read *et al.* Vet Rec 1992; 130: 59–60). This retrospective study of bovine digital skin cases at the Western College of Veterinary Medicine (WCVM) was prompted by the presentation of a Charolais bull in which biopsies confirmed a diagnosis of chronic digital dermatitis and the presence of spirochetal organisms. Ten other animals were identified with a diagnosis of digital dermatitis and the presence of spirochetal organisms was confirmed by either histopathology or Gram stains of tissue samples. These 11 cases occurred over the last 4 y. To our knowledge, there are only 2 other brief reports of spirochete-associated bovine digital dermatitis in Canadian cattle (4,5).

Nine of the 11 cases presented or submitted to the WCVM occurred in 3 dairy herds that had problems with multiple animals being afflicted with skin lesions and lameness. In each herd, a representative number of animals were sampled to allow a diagnosis to be made, but many other affected animals were not biopsied. The other 2 animals that were identified in this study included a dairy cow purchased by the WCVM for use in its teaching program and the Charolais bull that initiated this study.

The distribution of the lesions varied from involvement of the proximal plantar interdigital space ($n = 3$), the heel bulb ($n = 3$), the interdigital space with spread onto the heel bulb ($n = 4$), or multiple lesions of both the interdigital space and the heel bulb of the same foot ($n = 1$). The lesions were either ulcerated ($n = 1$), papillated ($n = 6$), or both ulcerated and papillated ($n = 4$). Animals that had more than 1 limb affected often had lesions that appeared grossly different from each other. For example, 1 limb may have had an ulcerated lesion, while the other limb may have had a proliferative lesion. Multiple lesions occurred in 3 animals. Three animals also had lesions involving the horn of the plantar or palmar aspect of the foot at the level of the coronet. The horn was soft and rubbery, and lifted away from underlying layers of horn. The lesions were described as underrunning of the heel, false soles, or simply cracks in the horn.

The histological appearance of all biopsies was similar. The epidermis in all lesions showed localized acanthosis due to keratinocyte hyperplasia. The elongated, finger-like projections consisted of layers of either ballooned, necrotic, or keratinized keratinocytes, with large numbers of neutrophils, necrotic cells, and bacterial colonies in the outer zones. The outer layers showed invasion by bacterial colonies and there were intraepidermal micropustules. The superficial dermis had mixed inflammatory cells and signs of congestion. Spirochetes were seen within both necrotic and viable outer proliferated epidermal cells, whereas other bacteria were limited to the necrotic layers. The spirochetes projected perpendicularly to the epidermal layers and appeared to invade cells. The papillary dermis had occasional fibrinous thrombi and hemorrhage. The deep dermis was also congested. There was perivascular and periadnexal infiltration with either lymphocytes and plasma cells or a mixed population of eosinophils, neutrophils, and plasma cells. The biopsies from 4 animals were also stained with an avidin-biotin immunoperoxidase method for papovavirus; all 4 were negative.

Bacteriological samples were submitted in 3 cases. In all 3 cases, smears of these samples were stained with Gram's stain, which confirmed the presence of spirochetes. Spirochetes were never successfully cultured under standard anaerobic conditions.

Treatment regimes in all these cases varied; due to the lack of subsequent examination, we cannot provide any information regarding the success or failure of the treatments.

Skin lesions have historically been described and named according to their location, physical appearance, and histological findings. The term digital dermatitis has been used primarily to describe a superficial moist exudative circumscribed ulcer with a white epithelial border and an area of proliferating tissue (3,6,7). Grossly, interdigital dermatitis is a similar lesion to digital dermatitis, but it occurs on either the plantar surface of the heel near the heel bulb or the dorsal surface of the interdigital skin (7,8). The epidermis is thickened and hyperemic, and exudation may cause crust formation.

Can Vet J 1996; 37: 35–37

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These conditions are initially very painful and prone to bleeding, but the pain lessens as the edges of the lesion begin to proliferate and form raised plaques (letter, Read *et al.* Vet Rec 1992; 130: 50–60). In reported cases where the progression of the lesions has been observed over a period of time, the more chronic lesions of digital dermatitis begin to look like verrucose dermatitis. The term verrucose dermatitis is used to describe a mass with fronds arising from the base of the thickened skin of the plantar or palmar surfaces of the feet (8). Interdigital papillomas are also highly papillated masses with long fronds, situated in the interdigital space. The descriptions of digital/interdigital dermatitis and verrucose dermatitis/interdigital papillomatosis are consistent with the ulcerative and proliferative lesions observed in the cases presented to the WCVM. We believe the proliferative lesions seen in these cases are a chronic manifestation of the acute ulcerative form.

Underrunning of the heel has been reported to occur in conjunction with digital dermatitis, particularly when the lesions are directly at the coronary band (3, letter, Nutter *et al.* Vet Rec 1990; 126: 200–201). It is not known whether underrun heels or other lesions of the heel horn are separate conditions occurring concurrently with digital dermatitis, due to similar predisposing environmental conditions, or if digital dermatitis predisposes the animal to lesions of the horn by inducing abnormal horn production (3).

The histological findings of the WCVM cases are similar to those reported for other cases of digital dermatitis (2,3,7,9). The location of the spirochetes at the junction of viable and necrotic tissue layers and the apparent invasion of spirochetes into the cells suggest a primary role of the spirochetes in the development of digital dermatitis. Spirochetes were the only organisms identified in close proximity to the viable cells.

Smears submitted for bacteriological evaluation confirmed the presence of spirochetes; however, the organisms were not successfully cultured. Successful culture techniques have recently been reported (5), but these protocols have not yet been established at the WCVM. Despite the inability to culture the spirochetes, the number of organisms observed was always sufficiently high to suggest a major role, either as a primary pathogen or as a significant secondary contaminant. There are reports describing the presence of spirochetes in biopsies of normal skin (9, letter, Blowey *et al.* Vet Rec 1992; 131: 39) and the role of the spirochetes in relation to the condition is clearly unknown. The inability to culture the organism will make it more difficult to confirm the pathogenic role of spirochetes, because test inoculations with pure cultures are not possible.

Regardless of the role of the spirochete, digital dermatitis appears to be infectious in nature. This observation is supported by reports of herd outbreaks in dairy farms (3, letters, Blowey, Vet Rec 1990; 126: 120; Blowey *et al.* Vet Rec 1992; 131: 39), especially after the introduction of new animals (3,9, letter, Nutter *et al.* Vet Rec 1990; 126: 200–201). Attempts to transmit digital dermatitis by injecting hxomogenates of the lesion into another cow have failed to cause the disease (6,9). These trials have been limited to inoculations of a single animal and are inadequate to assess the possible contagious nature of the disorder.

Viral etiologies, though suspected in proliferative lesions, such as, verrucose dermatitis and interdigital papillomatosis, due to their gross similarity to other skin lesions caused by papovavirus, have never been proven. Neither inclusion bodies nor viruses have ever been identified (6,7,9), and the use of autogenous vaccines has not been an effective therapy (7). The failure to identify papovavirus is consistent with the findings in the 4 biopsies we submitted for immunoperoxidase assays. The failure of virus isolation and autogenous vaccines, the absence of inclusion bodies, and the negative immunoperoxidase assays suggest that papovavirus is an unlikely etiological agent in digital dermatitis.

Digital dermatitis is most frequently observed in dairy cattle during winter housing and is often associated with hygiene or nutritional problems (3,6). The management of dairy cattle seems to predispose animals to develop this condition. Any condition that weakens the health of foot tissues can be expected to predispose cattle to any number of foot ailments. Beef cattle are rarely reported to develop digital dermatitis (9), and this is consistent with the cases seen at the WCVM. It is not known whether there is a higher occurrence of spirochetes in the environment of dairy cattle or if the management of dairy cattle results in more superficial skin lesions allowing the organisms to invade. No correlations between disease prevalence and age, parity, or stage of lactation have been identified. Different treatment regimes have been attempted with varying success. The response to parenteral antibiotic therapy appears to be unpredictable, whereas success with penicillin and ceftiofur has been reported (letter, Read *et al.* Vet Rec 1992; 130: 59–60), though others have found no response to penicillin, streptomycin, tetracycline, cephalexin, or sulphonamides (3,7,10). Footbaths are also a controversial technique for treatment and there have been variable success rates. Generally, walk-through footbaths are not as effective as standing baths (11). Footbaths of 5% formalin have been reported to have a range of responses, including exacerbation of digital dermatitis (letters, Blowey, Vet Rec 1990; 126: 120; Nutter *et al.* Vet Rec 1990; 126: 200–201), failure to reduce new cases (3,10, letter, Read *et al.* Vet Rec 1992; 130: 59–60), and adequate control but not elimination of the condition (letter, Clark, Vet Rec 1990; 126: 120). Copper sulphate does not provide control of the lesions (3, letter, Nutter *et al.* Vet Rec 1990; 126: 200–201). It has been suggested that zinc sulphate (20%) is adequate for control and treatment of mild cases (letter, Nutter *et al.* Vet Rec 1990; 126: 120–121). The greatest success for control, using only footbaths, appears to occur with tetracycline (4g/L or greater) (3, letter, Blowey, Vet Rec 1990; 126: 120).

If digital dermatitis does progress from an early ulcerative form to a later chronic proliferative form, it is not surprising that the response to treatment has been variable. In the early ulcerative form, the organism is probably more exposed to the active ingredients of topical agents and footbaths than more chronic proliferative lesions. The varying degree of congestion seen in the dermis of lesions may influence the penetration and hence the effectiveness of parenteral antibiotics. The greatest overall success in treatment that has been reported has been achieved by debriding ulcerative lesions and by debulking proliferative lesions (3,7,8, letter, Blowey

et al. Vet Rec 1992; 131: 39). Postoperative care consisted of applying a tetracycline spray (frequently containing gentian violet) (3,6,8,11) or a powder dressing of copper sulfate or sulfanilamide, along with parenteral penicillin (7).

If the cases submitted to the WCVM are any indication, digital dermatitis is probably seen frequently by practitioners. Little is understood about the etiology, pathogenesis, progression, and treatment of all forms of bovine digital dermatitis. Minimal work has been done to study the progression of skin lesions, and this may explain some of the confusion currently existing in regard to which lesions represent different disease processes. If the prevalence of digital dermatitis resembles that seen in the United Kingdom, it may be responsible for significant economic losses. Many questions regarding the presence of spirochetes still need investigation to develop an understanding of the role of these organisms in digital dermatitis. Studies examining the progression of the disease and treatment regimes would be very valuable to clinicians to help with adequate identification and management of cases. CVJ

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