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THE CURRENT STATE OF KNOWLEDGE ON (PAPILLOMATOUS) DIGITAL DERMATITIS IN DAIRY CATTLE: WITH PARTICULAR REFERENCE TO CONTROL

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Introduction

Digital dermatitis was first described in Italy in 1974 (Cheli and Mortellaro, 1974) and in the UK in 1988 (Blowey and Sharp, 1988). The disease was reported in the USA in 1980 as interdigital papillomatosis (Rebhun et al., 1980). Read and Walker discussed a similar but more often proliferative disease, papillomatous digital dermatitis (footwarts), in 1994 (Read and Walker, 1994a; Read and Walker, 1994b). Histopathologic and immunohistochemical evidence indicate that papillomatous digital dermatitis (PDD) and digital dermatitis (DD) are the same disease (Read and Walker, 1998a), therefore, the abbreviation (P)DD will be used throughout the text to designate both terms. Dairy producers reported seeing (P)DD in California in the mid-1980's but most observed (P)DD on their dairies for the first time in the early 1990's (Rodriguez-Lainz et al., 1996b; Wells et al., 1997)). (P)DD has been reported in many countries of the world, most commonly on confinement dairies (Cruz et al., 2001; Demirkan et al., 2000; van Amstel et al., 1995) but has been reported on pastured cattle also (Blowey and Sharp, 1988; Rodriguez-Lainz et al., 1999; Somers et al., 2003).

(P)DD is one of the most common causes of lameness and is an animal welfare concern for the dairy industry. Economic losses result from premature culling, decreased milk production, decreased reproductive efficiency, and cost of treatment (Hernandez et al., 2002; Rebhun et al., 1980). British researchers calculated the economic loss from a case of (P)DD to be approximately 114 EUR per cow/lactation (Esslemont and Peeler, 1993).

Epidemiology, Pathogenesis, and Etiology

The most common location of (P)DD lesions is on the palmar surface of the rear foot near the skin-horn junction bordering the interdigital space (Read and Walker, 1998b). Histopathologically, (P)DD is characterized by a combination of ulcerative and proliferative changes consisting of ulceration of tips of dermal papillae, epidermal hyperplasia with parakeratosis and hyperkeratosis, colonization and invasion by profuse numbers of spirochetes, and inflammation (Read and Walker, 1998b). Lesions are circumscribed, erosive to papillomatous, painful, and often surrounded by hyperkeratotic skin with hypertrophied hairs (Read and Walker, 1998b). Lesions are found less commonly on the palmar rear feet near the dewclaws and on both hind and front feet near the dorsal commissure of the interdigital cleft.

The precise etiology of (P)DD is unknown but is considered to be multifactorial with environment, management, and microbial factors (Read and Walker, 1998b; Rodriguez-Lainz et al., 1996a; Rodriguez-Lainz et al., 1996b; Rodriguez-Lainz et al., 1998). Earlier research identified that two risk factors for a high prevalence of (P)DD are wet conditions and purchasing replacements from off-premises (Rodriguez-Lainz et al., 1996a; Wells et al., 1997; Wells et al., 1999). Other management conditions that may be involved in (P)DD are those thought to contribute to poor digital skin health, i.e. any condition that causes poor foot hygiene.

The microbes identified most consistently from active lesions are spirochetes of the genus Treponema (Borgmann et al., 1996; Choi et al., 1997; Collighan and Woodward, 1997; Demirkan et al., 1998; Demirkan et al., 1999b; Doherty et al., 1998; Döpfer et al., 1997; Moter et al., 1998; Read et al., 1992; Walker et al., 1995; Walker et al., 1998). These spirochetes comprise the bulk of the colonizing mat of microbes found on active lesions and are also found invading the epidermis and dermis (Demirkan et al., 1998; Moter et al., 1998; Read et al., 1992; Walker et al., 1995). Treponemes isolated from (P)DD are similar to those that cause periodontal disease in humans (Edwards et al., 2003a; Edwards et al., 2003b). The infectious component of (P)DD may be complex, possibly involving several other anaerobic bacteria which may play a symbiotic role (Read et al., 1999; Read and Walker, 1997; Walker et al., 1994). However, it appears that spirochetes may play a primary pathogenic role because a sequential ultrastructural study of the experimentally transmitted disease in calves showed that spirochetes were the first microbes to invade and colonize the epidermis and dermis (Read and Walker, 1996).

Other bacteria have been less consistently identified (Demirkan et al., 1999b; Murray et al., 2002; Schütz et al., 2000). Three distinct phylogenetic types of Treponema spp. have been identified by US researchers (Walker et al., 2001). Workers from Germany have identified another, novel strain (Schrank et al., 1998) and other strains may be involved (Trott et al., 2003). There is no evidence of viral involvement (Read et al., 1995b; Zemljic, 1994).

In a California study, antibodies against two antigenically distinct Treponema spp. were increased on dairies with (P)DD compared to (P)DD-free dairies (Walker et al., 1997). Cattle with (P)DD on a high prevalence dairy were much more likely to have antibodies against Treponema spp. than were cattle without lesions on the same dairy (Walker et al., 1997). Each of the two Treponema spp. produced specific antibodies and did not cross-react with each other or with other common spirochetes associated with diseases of cattle (Walker et al., 1997). Workers in Iowa were able to demonstrate that the Treponema spp. elicited cellular as well as humoral immune response in cows with active (P)DD lesions (Moeller et al., 1999). Higher prevalence of clinical disease in younger animals of an endemically affected herd suggests that immunity may develop in older cows or that younger cows are more susceptible (Read and Walker, 1994b).

Recent research in Sweden found that herds that ranked high for dermatitis (DD) also ranked high for verrucose dermatitis ((P)DD), heel-horn erosion, and interdigital hypertrophy (Manske et al., 2002a). These researchers made no distinction between ID and DD since interdigital dermatitis and early digital dermatitis are very similar and occur in the same area, but they did make a distinction between erosive digital dermatitis (DD) and verrucose dermatitis (PDD). Several others have proposed that ID and DD are similar diseases (Blowey et al., 1994; Read and Walker, 1998b; Vokey et al., 2001; Walker et al., 1995; Walker et al., 2002).

Different flooring systems have been associated with reduced occurrence of (P)DD. Swedish workers (Hultgren and Bergsten, 2001) found that the odds ratio for (P)DD was 0.23 for tie stall cows on rubber slats when compared to tie stall cows with solid flooring. Dutch workers compared claw health on cows housed on slatted floor, slatted floor with scraper, solid concrete floor, straw yard, and a zero-grazed group (Somers et al., 2003). They found that cows in straw yards had far fewer claw disorders and those cows on the slatted floor with scraper had less ID and (P)DD than the cows on the slatted floor. The flooring systems in these studies that resulted in fewer cases of (P)DD were those in which cows had better foot hygiene.

Transmission

The mode of transmission is unknown but clinically and subclinically affected cows and fomites might be sources of infection for naive herds (Rodriguez-Lainz et al., 1996a; Wells et al., 1997; Wells et al., 1999). There have been numerous anecdotal reports from farmers, veterinarians, and claw trimmers that they first observed (P)DD on dairies after livestock from off premises were purchased.

Read and Walker hypothesized that animals may be predisposed to (P)DD by prolonged exposure of digital skin to oxygen-depleted, wet, organic material (Read and Walker, 1994b). They were able to achieve experimental transmission to calves using scrapings from active lesions and found that prolonged moisture and reduced access to air were necessary for successful transmission (Read and Walker, 1996; Read, 1997). Sequential ultrastructural study of experimentally transmitted (P)DD in calves demonstrated that spirochetes were the first bacterial morphotype to invade and colonize the epidermis and dermis (Read, 1997).

Treatment and Control

Early anecdotal reports indicated that (P)DD lesions responded to treatment with topical antibiotics, thereby supporting the hypothesis of bacterial etiology. Numerous studies demonstrated a clinical response to antibiotics applied as a topical spray treatment or under a bandage (Berry et al., 1996; Berry et al., 1998; Berry et al., 1999b; Berry et al., 1999a; Berry and Maas, 1997; Blowey, 1994; Blowey and Sharp, 1988; Britt et al., 1996; Britt and McClure, 1998; Brizzi, 1993; Graham, 1994; Guard, 1995; Guterbock and Borelli, 1995; Hernandez et al., 1999; Read and Walker, 1998b; Reed et al., 1996; Shearer et al., 1998; Shearer and Elliott, 1994; Shearer and Elliott, 1998). Non-antibiotic products have also been reported to be efficacious (Britt et al., 1996; Britt and McClure, 1998; Hernandez et al., 1999; Read and Walker, 1998b). The most commonly used topical antibiotic treatments are oxytetracycline, lincomycin, and lincomycin/spectinomycin. Antibiotic milk residue violations due to topical application of antibiotics have not been reported (Britt et al., 1999; Brizzi, 1993; Hartog et al., 2001; Mortellaro, 1994). Parenteral antibiotics have not been consistently effective.

In more recent studies, oxytetracycline applied as a topical spray was more effective than either hoof trimming alone or glutaraldehyde as a topical spray (Manske et al., 2002c). The same researchers also found that claw trimming twice per year was effective in reducing laminitis related lesions but not moderate-to-severe heel horn erosion or (P)DD (Manske et al., 2002b).

US workers treated (P)DD-affected cows with either lincomycin or a non-antibiotic cream (soluble copper with peroxide and a cationic agent, Victory Foot Cream®, Westfalia Surge, Inc.) under a bandage (Moore et al., 2001). They found that both the lincomycin and the non-antibiotic cream significantly reduced pain, lesion activity, lesion size, and decision to retreat when examined 29 days after treatment. The lincomycin was significantly more effective than the cream in reducing lesion size and avoiding retreatment. This study also found that cows in the 3rd or greater lactation were more likely to have a healed lesion than cows in lactation 1 or 2 when examined 29 days after treatment (Moore et al., 2001).

British workers compared valnemulin to lincomycin as a topical spray for treatment of (P)DD (Laven and Hunt, 2001). Each animal was treated twice, 48 hours apart with either 25 ml of 0.6 mg lincomycin/ml or 25 ml of 100 mg valnemulin/ml. Both treatments resulted in significant improvement in (P)DD when examined 14 d after treatment (Laven and Hunt, 2001).

Earlier research reported that footbaths containing 5% formalin (Blowey and Sharp, 1988; Brizzi, 1993; Mortellaro, 1994), lincomycin (1-4 g/l) (Brizzi, 1993), oxytetracycline (1-4 g/l) (Brizzi, 1993; Guard, 1995; Mortellaro, 1994), copper sulfate (0.25-1 g/l) (Guard, 1995; Mortellaro, 1994), or zinc sulfate (20%) (Mortellaro, 1994) provided control of the disease in infected herds.

Recent footbathing experiments in Sweden found that a higher proportion of cow's feet affected by (P)DD were cured by acidified copper sulfate (Hoofpro+®, SSI, Julesburg, CO, USA) than by water alone (Manske et al., 2002c). These researchers also noted that the copper solution had no preventive effect.

US workers found that the use of a proprietary, non-antibiotic product (Double Action™, West Agro, Inc., Kansas City, MS, USA) reduced the prevalence of (P)DD lesions requiring foot wrapping with lincomycin or oxytetracycline at claw trimming (Seymour et al., 2001; Seymour et al., 2002). Other workers in the US found that another proprietary, non-antibiotic product (Victory®, Westfalia Surge, Inc., IL, USA) improved lesion scores on cows with (P)DD 12 d after treatment (Gradle et al., 2002). No concurrent control treatments were used in these experiments, however.

British researchers compared 3 non-antibiotics (copper sulfate (2%), formalin (6%), and peracetic acid (1%)) to erythromycin (2.1 g/L) in footbaths for the treatment of (P)DD (Laven and Hunt, 2002). Cow's feet were cleaned with a hose before they were walked through a 3 m long footbath. Each cow spent at least 20 seconds in the footbath. Mean lesion scores were significantly reduced with all 4 treatments and there were no significant differences between any of the groups (Laven and Hunt, 2002). These workers used erythromycin as a positive control in this study because it had been previously demonstrated to be efficacious (Hartog et al., 2001; Laven and Proven, 2000) and they were interested in whether the non-antibiotics could be substituted for the antibiotic. These workers noted that the test herd had (P)DD as a mild, endemic disease and that they only observed cows for 21 d following treatment.

Earlier British research (Arkins et al., 1986) found that 5% formalin footbaths improved interdigital lesions but did not prevent new individual interdigital lesions. Blowey reported anecdotal success using prolonged formalin footbathing as proposed by Adrian Gonzales at the International Ruminant Digit Symposium in Banff in 1994 (Blowey, 2000). There is speculation that formalin used in moderation might be less damaging to the environment than copper sulfate but the human health hazards of formalin are considerable.

Footbathing with antibiotics is the most common treatment for (P)DD in the UK (Laven, 2001), whereas antibiotic footbaths are rarely used in the US and topical antibiotic sprays or footwraps are more common (Shearer et al., 1998; Shearer and Elliott, 1998). Cows in the US that use footbaths walk through them when exiting the milking parlor on the way back to their pen. Most cows pass through the footbaths rapidly and return immediately to the freestall barns. This is in contrast to European studies where cows are made to stand in the footbaths and then in a clean environment for a period of time before returning to their pens (Hartog et al., 2001; Laven, 2001).

Up to 60% of successfully treated cows may develop recurrent lesions in 7 to 15 weeks (Berry et al., 1999a; Read and Walker, 1994b). Spontaneous regression of lesions and resolution of lameness may occur rarely. Chronic or recurrent cases in otherwise healthy adult cattle have been reported suggesting that if immunity to (P)DD does develop, it may be incomplete or temporary.

Diagnosis

Identifying the prevalence or presence of (P)DD is the first step to controlling the disease. Zemljic studied the histopathologic criteria for (P)DD diagnosis based on loss of the epidermal barrier, invasion by spirochetes, and inflammation in Slovenia dairy farms (Zemljic, 2000). Results from this study showed that 79% of biopsies submitted satisfied these criteria. Taking skin biopsies and submitting them for histopathology is not a practical method for diagnosing disease for treatment. Another screening method for detection of this disease was evaluated in Chilean dairies. This diagnostic method, known as water-jet test (WJT) with bright light, is based on gross appearance, location, and lesion sensitivity (pain) to the water jet (Rodriguez-Lainz et al., 1998). Efficiency of WJT was compared to examination of each foot on restrained cows in a chute (gold standard). The WJT can be used as a cost-efficient method for (P)DD diagnosis with a sensitivity of 0.72 and a specificity of 0.99 (Rodriguez-Lainz et al., 1998). Evaluation of antibody response to (P)DD-associated Treponema spp. is another method used to determine prevalence of (P)DD in terms of exposure rather than clinical infection. ELISA for serum antibodies to (P)DD treponemes was significantly higher on cows with lesions than on cows without lesions (Walker et al., 1997).

Vaccination

While many treatment and control measures such as antibiotic and non-antibiotic topical sprays, footwraps, and footbaths, as well as regular hoof trimming have been found to be effective control measures, they are expensive, labor intensive, and the recurrence of the disease is still high (Berry et al., 1999a; Read et al., 1995a; Read and Walker, 1994b; Shearer et al., 1998; Shearer and Elliott, 1998; Zemljic, 2000). An efficacious and cost-effective vaccine against (P)DD would prevent disease and, thus, decrease treatment and other disease associated costs.

Although (P)DD is multifactorial and the precise etiology has not been determined, there is compelling evidence that invasive spirochetes play a major role either as primary or secondary pathogens in (P)DD lesions (Borgmann et al., 1996; Choi et al., 1997; Collighan and Woodward, 1997; Demirkan et al., 1998; Demirkan et al., 1999a; Demirkan et al., 1999b; Doherty et al., 1998; Döpfer et al., 1997; Keil et al., 2002; Moter et al., 1998; Read et al., 1992; Walker et al., 1995). Immunocytochemical staining showed that spirochetes in skin lesions were identified by polyclonal antisera to Borrelia burgodorferi, Treponema denticola, and Treponema vincentii but not to monoclonal antisera for B. burdorferi or T. pallidum (Demirkan et al., 1998). Two strains of Treponema spp. were cultured and characterized as the most predominant strains of spirochetes associated with (P)DD (Walker et al., 1995; Walker et al., 1998). These and other studies have shown that the treponemes associated with (P)DD are similar to but distinct from the treponemes involved in human periodontitis (Demirkan et al., 1999b; Edwards et al., 2003a; Edwards et al., 2003b; Schrank et al., 1998; Trott et al., 2003).

Results from a serology study with control groups suggests that anti-Treponema antibody titers in vaccinated animals with Treponema bacterin (Novartis Animal Health, Inc.) increased 5.6, 10.4 and 27.2-fold after one, two and three doses, respectively, while no change in ELISA antibody levels was detected on placebo controls (Keil et al., 2002). Another clinical trial where 150 out of 300 healthy adult Holstein cows were vaccinated with an inactivated autogenous Treponema bacterin (Novartis Animal Health, Inc.) showed a considerably higher (P)DD incidence on control animals (14.7%) than on vaccinates (1.3%) 45 days after the third vaccination (Keil et al., 2002). Similar results were obtained on a second controlled clinical trial where 80 Holstein heifers were vaccinated with autogenous Treponema bacterin and housed in low (P)DD incidence growing pens. After completion of vaccination series (30 days), they were moved to a high incidence (breeding) pen. A 74% and 63% reduction of (P)DD lesions was found in vaccinates at 9 and 18 weeks post-vaccination respectively (Keil et al., 2002). In these studies, immunization of cattle with Treponema bacterin lead to a significant reduction in clinical disease.

In a German study, no prophylactic or therapeutic effect of two herd-specific vaccines against (P)DD was obtained in a controlled clinical trial on a free-stall dairy. After isolating several anaerobic bacteria from (P)DD lesion biopsies, two vaccines were developed. Vaccine 1 had isolates from active (P)DD lesions and contained: Porphyromonas spp., Fusobacterium necrophorum, Bacillus stercoris, Prevotella bivia, and Peptostreptococcus indolicus. Vaccine 2 contained all the isolates from vaccine 1 as well as Treponema spp. (20% of total count). A placebo solution with no antigen was prepared as treatment 3. The vaccine with no treponemes showed evidence of a positive effect one year after the first vaccination. The vaccine with Treponema spp. showed no significant prophylactic or therapeutic effects on prevalence or severity of typical (P)DD lesions (Schütz et al., 2000).

An early Treponema bacterin study in California found the vaccine may have a reducing effect on lesion size and number but did not prevent transmission (Oliver, 1999). The study was conducted with vaccinated and control calves that were and then challenged using the experimental challenge model developed by Read and Walker (Read and Walker, 1996; Read, 1997).

In recent controlled, blind field studies to determine whether Treponema bacterin provided prophylactic and/or therapeutic effects for controlling (P)DD in cattle (Berry et al., 2004), a total of 420 and 740 Holstein cows were enrolled from two commercial California dairies with (P)DD prevalence of 27% and 29% respectively at pre-vaccination parlor evaluation. All lactating cows from each herd were vaccinated with either Treponema bacterin (under development by Novartis Animal Health, Inc. and conditionally licensed by USDA) or placebo (adjuvant with no Treponema) a. The total herds of cows were vaccinated 3 times at 3 week intervals per label instructions, while cows were restrained in stanchions for their regular, daily estrous detection and breeding. This meant that cows were in all stages of lactation and reproductive status in contrast to the Nebraska study discussed later in this paper. Investigators were blinded as to which cows received vaccine or placebo. Study cows were grouped according to their disease status prior to treatment (visible lesion, no visible lesion) and treatment received (vaccine, placebo). After completion of vaccination, all cows were visually examined for evidence of (P)DD monthly for 6 months. The screening test used was observation with a bright-light and water-jet test (WJT) in the parlor during milking. Reliable hoof trimmer records were examined to make sure (P)DD affected cows were not missed at the parlor examinations. A sub-sample of vaccine and placebo cows with no visible lesions were bled pre-vaccinating and at each of the observation periods for ELISA testing for Treponema antibodies.

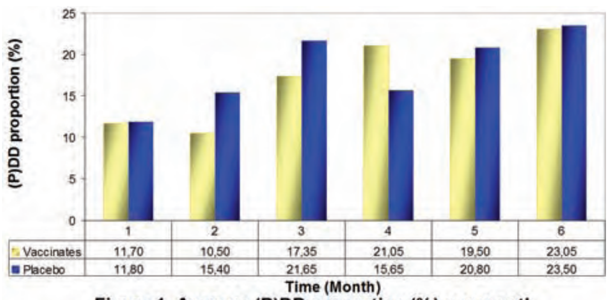

Figure 1. Average (P)DD proportion (%) per month for cows without visible lesions prior to vaccination with *Treponema* bacterin or placebo

A series of z-tests comparing the monthly (P)DD proportions of cows without visible pretreatment lesions from both dairies combined found no significant prophylactic effect (p-value averages ranging from 0.224 to 0.802), shown in Figure 1. In general, the proportion of vaccinates with subsequent (P)DD was lower than placebo groups during all months of observation, except during month 4. Therapeutic effects of Treponema bacterin among cows with visible pretreatment lesions were also non-significant (p-values ranging from 0.118 to 0.940). The proportion of animals with (P)DD in vaccinated animals was not significantly different from that of placebo animals at any of the observation times (not shown).

ELISA for serum antibodies to (P)DD-associated Treponema spp. revealed that a high proportion (34/78 or 44%) of cows with no visible lesions had titers compatible with exposure ($\geq$1600) prior to treatment (Table 1). These preliminary serological results indicate that many animals considered naive by visual observation actually had titers consistent with exposure, which may have contributed to the results indicating no benefit. Statistical analyses have not been performed but fewer of the ELISA negative vaccinates developed (P)DD lesions during the study when compared to the ELISA negative placebo cows.

Table 1. Comparison of visual observation and ELISA testing for Treponema antibodies prior to vaccination with Treponema bacterin or placebo (adjuvant with no Treponema antigens.

	ELISA		
Visual observation	Positive	Negative	TOTAL
Positive	6	4	10
Negative	34	34	68
TOTAL	40	38	78

In contrast to the above study, a study in Nebraska, USA found that a different Treponema bacterin (TrepShield HW®, Novarits Animal Health, Inc.) was efficacious in preventing new cases of (P)DD in heifers and cows (G.A. Anderson, Novartis Animal Health, Inc., personal communication). TrepShield HW® is fully licensed with the US Department of Agriculture. In this study heifers were vaccinated prior to calving and cows were vaccinated during the dry period in contrast to the California trials in which all cows in the herds were vaccinated at the same time. Cows and heifers were randomly assigned to vaccine or control groups. Cows and heifers were classified as (P)DD negative or positive based on the bright light and water jet test. The prophylactic portion of the study (prevaccination (P)DD negative cows and heifers) included 368 animals. The cumulative incidence is presented in Table 2.

Overall, the incidence of (P)DD was significantly lower in vaccinated compared to control animals. A statistical difference in incidence between vaccinates and controls was found for cows and heifers combined and heifers alone, but not for cows alone. In this study, serology was not performed. Based on the California studies with serology on dairies having a similar pre-trial prevalence to this Nebraska study (27%), we might speculate that a sizable proportion of the (P)DD negative animals in this study were not naive. If that were true, the vaccine would be more efficacious than these results indicate.

In the California study, vaccination of the whole lactating herd (in herds with a high prevalence) did not provide significant prophylactic or therapeutic effects to cows studied during 6 months. We speculate that using the vaccine on animals before they are exposed to the disease may prove to be more beneficial. On commercial dairies in the US those animals are most likely to be the breeding age heifers before they are exposed to the lactating cow herd.

Table 2. Cumulative incidence during the 4 weeks following calving, relative risk, and vaccine efficacy of a Treponema bacterin in vaccinated and control cows and heifers without visible (P)DD lesions at the beginning of the trial (prophylactic trial)

	Cumulative incidence (CI)
Overall	
Vaccinated	18.6% (33/177)[a]
Controls	28.8% (55/191)
Heifers	
Vaccinated	14.6% (13/89)[b]
Controls	26.6% (27/101)
Cows	
Vaccinated	22.7% (20/88)[c]
Controls	31.1% (28/90)

[a] p=0.023, [b] p=0.041, [c] p=0.208

Conclusions

It appears, that for all we have learned about (P)DD these last 30 years, there is still much more that we do not know. There are still many unanswered questions about the precise etiology, whether the treponemes are primary or secondary pathogens, the virulence factors for the treponemes, and where the treponemes live when they are not causing disease. Treatment with topical antibiotic and non-antibiotic products helps control (P)DD but recurrence is high and treatment must be on going. A new Treponema bacterin might offer some help in preventing (P)DD if we can vaccinate animals before they are exposed. The factors that seem to receive the least attention and, perhaps, might be the most important in controlling this disease are the hygiene of the environment for the cow's feet and biosecurity, especially when purchasing animals from off premises.

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AETIO-PATHOGENESIS OF ANAEROBIC INFECTIONS ASSOCIATED WITH BOVINE LAMENESS AND SOME HUMAN DISEASES

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Introduction

In clinical veterinary practice, infectious lameness has been described in textbooks from the early 1800s. Known colloquially as 'the fouls', specific lesions were accurately described: the shag foul was a circular lesion 2 cm diameter on the heel similar to greasy heels in horses and sounds similar to digital dermatitis; the stinking foul was an interdigital necrosis that was, almost certainly, interdigital necrobacillosis; the frog foul was a space-occupying lesion within the interdigital space but without any damage to the integument, the condition we recognise now as interdigital hyperplasia (Knowlson 1819). During the 1930s, infectious causes of lameness in both cattle and sheep were considered important only with regard to diagnosis of Foot-and-Mouth disease (Woolridge 1934), not for any economic or welfare reasons.
Today, cattle lameness is considered a major welfare issue in many countries where intensive dairy farming is commonplace. Surprisingly it is two infectious diseases associated with lameness, digital dermatitis in cattle and new variant footrot in sheep, which are causing currently the greatest problem for livestock farmers. The aetiopathology of both is unclear and hence control measures are largely ineffective (Demirkan et al 1999). Treatment and control is expensive in terms of time and labour, and there is concern that disposal of footbath solutions used for treatments may pollute the environment.

Aetiology

The list of microorganisms associated with infectious lameness in cattle, mostly facultative or obligate anaerobes, is large and expanding slowly. The most common diseases and the infectious agents associated with them are listed in Table 1, together with suitable references. Until recently, it was not possible to isolate and grow Treponeme spp in pure culture and much of the evidence of their association with digital dermatitis is based currently on serology. Otherwise, all other microorganisms have been isolated from lesions and identified by standard microbiological techniques.

Risk factors for digital skin infections

Gross anatomy of the interdigital space

The vertical distance between the ground and the cranial and caudal borders of the interdigital space varies consistently in adult cattle (see Table 2). These results suggest that the caudal aspect of the interdigital space is always closer to the ground and adjacent hairy skin is vulnerable to repeated and continuous contact with slurry, especially in housed cattle. This is the case more so for hind limb digits than those of fore limbs ,ince many cows stand half-in cubicles with their hind feet in the slurry passage. The continuous contact of the hairy skin of the heel of hind limbs with slurry may cause focal hydropic maceration of the epidermis at this site and predispose it to bacterial invasion.

Microtrauma to skin

The integument of the bovine digit is designed to form an effective barrier between the environment that surrounds it and the functional tissue within it. Thus, a keratinised hard horny capsule encases the 3rd phalanx and distal interphalangeal joint of all claws. The skin of the interdigital space between each claw is also modified. Sweat glands and hair follicles are absent and the stratum corneum of the epidermis comprises of anuclear stratified squamous keratinised cells arranged in layers up to 35 cells thick. This is a very substantial flexible protective barrier to external insults. Microorganisms can penetrate such a structure only following mechanical trauma that allows opportunistic pathogens access to adhere to the deeper layers of the epidermis. Only then can keratolytic enzymes produced by pathogens such as D. nodosus, or exotoxins produced by F. necrophorum, break down the epidermal barrier to expose sensitive and susceptible underlying dermal tissue to inflammatory changes or invasion by other opportunistic pathogens.
The hairy skin adjacent to the coronary band and interdigital space is not modified from that found elsewhere. It remains an effective mechanical barrier. However, the integrity of the epidermis is affected adversely by exposure to prolonged moisture and reduced access to air. The resultant hydropic maceration may predispose skin to infection by Treponeme spp to produce clinical lesions typical of digital dermatitis (Read and Walker 1998).

Biology of anaerobic pathogens associated with human disease

Human periodontal disease has many similarities with infectious lameness in cattle; the bacterial profile, a stratified epithelium that is invaded, a 'triggering event' that precipitates epithelial and connective tissue necrosis, a susceptible host. Syphilis, like digital dermatitis, has been associated with a Treponeme infection. In periodontal disease, the focus of research has been to understand the interactions between various microorganisms isolated from diseased gingiva; with syphilis, it is the biology of Treponemes associated with their pathogenicity.
Some of these research outcomes are described below:
Attachment and colonisation of epithelial surfaces
The pathogenic Treponeme pallidum attaches to its host cells and invades epithelium whilst non-pathogenic Treponeme spp do not have this ability. This adherence factor appears to contribute to prolonged bacterial sur-

vival, motility and virulence. Cell surface structures, known as adhesins, interact with extracellular matrix molecules (EMMs) found on the host cell surface such as firbronectin, collagens and laminins. Bacterial adhesins have been found on T. denticola, a near-relative to the Treponeme spp isolated from clinical cases of digital dermatitis and new variant footrot, and exhibit specific attachment to laminins (Cameron 2003). The pathogenic Porphyromonas gingivalis has its own adherence factors that bind with host cell EMMs on the gingival epithelium (Agnani et al 2003).

Role of matrix metalloproteinases (MMPs)

MMPs are a gene family of zinc metalloenzymes associated with degradation of extra-cellular elements of host cells such as collagens and proteoglycans. There are three classes, defined according to their substrate specificity: collagenases degrade collagen produced by fibroblasts and monocyte/macrophages; gelatinises degrade denatured collagen and elastin; stromelysins have a wide specificity including proteoglycans, laminin, fibronectin and IX collagens. MMP activity is counterbalanced by host tissue inhibitors (TIMP-1). Any disease condition that upregulates MMP expression but not TIMP-1 increases matrix turnover (Nicod and Dayer 1999). Recently, Choi et al (2003) found that T. denticola can upregulate MMP expression, especially gelatinase.

Environmental influence on microbiological function

A study of pathogenic spirochaetes has produced evidence that the bacterial genome is expressed differentially according to the microenvironment that surrounds it. For example, temperature, serum deprivation and the mammalian environment may all affect synthesis of Borrelia burgdorferi proteins associated with cell regulation or signalling (Roberts et al 2002). Another example can be found related to protease production by the human colonic bacteroide Bacteroides fragilis. Its protease formation, essential for bacterial growth, is stimulated in the presence of excess carbohydrate and strongly inhibited by high peptide concentrations in the gut (MacFarlane et al 1992).

Microbial coaggregation and synergy

Examples of this exist within the microbiological profile of the healthy human intestine. Members of the genus Bacteroides ferment soluble polysaccharides such as pectin and starch; other anaerobes such as Bifidobacterum spp. and P.asacchrolytica break down insoluble complex polysaccharides like mucin. Another example relates to the anaerobe P. melaninogenicus. If this organism is added to an avirulent mixture of human oral bacteria this complex becomes uniformly infective and causes severe abscess formation in experimental animals (Socransky and Gibbons 1965). A similar synergy exists when contaminant anaerobes such as F. necrophorum and Arcanobacterium pyogenes are present in the bovine uterus post-partum, causing a severe endometritis that may result in significantly lowered fertility of affected cows.

Periodontal disease begins with the adherence of certain bacteria to the tooth enamel surface coated with salivary glycoproteins. The Gram +ve Streptococcus sanguis adheres to enamel initially. Then, bacterial coaggregation occurs which involves cell-associated lectins or fimbriae present on its cell surface. Other bacteria such as Actinomyces viscosus possess receptors that can bind specifically to these fimbriae and the bacterial profile at the gingival surface builds up to produce an initial inflammatory response. Microbial coaggregation can be inhibited by glycoproteins present in saliva (Cisar 1982).

Host humoral immune response to anaerobes

The specific activity of bovine IgG2 against spirochaetes associated with clinical digital dermatitis lesions is similar to that found for diverse strains of Gram -ve anaerobic bacteria isolated from subgingival plaque in humans. The conclusion could be that these bacteria are associated immunologically with development of their respective lesions. This humoral response could be significant in several ways:

a) IgG can bind with polymorphonuclear inflammatory cells (PMNs) to release lysosomal enzymes, thereby disrupting basement membranes and allowing microorganisms to penetrate disrupted epithelium;

b) compliment-activating antigen-antibody complexes may inhibit phagocytic activity of PMNs

c) sensitised lymphocytes release lymphokines which inhibit macrophage migration. The degree of tissue necrosis associated with different lesions may be a reflection of both the microbial profile associated with disease but also the variation in the host's humoral immune status.

Conclusions

The parallels between infectious lameness in ruminants and a variety of human diseases associated with anaerobic Gram -ve organisms are striking. Not only are the microorganism profiles similar but the humoral antibody responses comparable for healthy and diseased patients. Such comparative studies could suggest the direction that future research should take: the significance of different microbial profiles associated with lesions; host-parasite interactions and the role of humoral antibodies; virulence factors present in Treponeme spp. isolated from different sites within an animal and compared with those found in lesions.

Table 1. Microorganisms associated with infectious causes of lameness in cattle

Disease	Alternative name	Microorganisms isolated	Reference
Digital dermatitis	Mortellaro disease	Bacteroides spp	Roztocil et al (1988)
	Digital papillomatosis	Campylobacter faecalis	Sabo et al (1988)
	Papillomatous digital	Clostridium spp	Koniarova et al (1993)
	dermatitis	Fusobacterium spp.	Dopfer et al (1997)
	Strawberry footrot	Peptococcus asaccharolyticus	Choi et al (1997)
	Raspberry heel	P. saccharolyticus	Wallis et al (1997)
	Hairy warts	Peptostreptococcus spp	Demirkan et al (1999)
	Hairy footwarts	Serpens spp	Schroeder et al (2003)
		Treponema spp	
Interdigital necrobacillosis	Interdigital phlegmon	Bacteroides thetaiotaomicron	Flint and Jensen (1951)
	Infectious pododermatitis	Fusobacterium necrophorum	Hartwigk (1973)
	Foul-in-foot	Prevotella melaninogenicus	Berg and Loan (1975)
	Clit-ill	Porphyromonas asaccharolytica	Berg et al (1994)
	Hoof-rot	P. levii	Morck et al (1998)
	Panaritum		
Peracute interdigital necrobacillosis	Super foul	F. necrophorum	Cook and Culter (1995)
		P. melaninogenicus	
		Dichelobacter fragilis	
Interdigital dermatitis	-	Arcanobacterium pyogenes	Egerton and Parsonon (1966)
		Dichelobacter nodosus	Berg (1981)
		F. necrophorum	Masalski (1986)

Table 2. Vertical height (cm) between ground surface and cranial and caudal borders of the interdigital space in 106 front and 123 hind feet of adult cattle

Limb	Site	Perpendicular height (cm) between ground surface and interdigital space				
		Mean	Minimum	Maximum	t value	p
Front	Cranial	6.5	5.0	8.4	-47.6	0.001
	Caudal	3.6	2.3	5.4		
Hind	Cranial	6.5	5.4	7.7	-59.9	0.001
	Caudal	3.0	1.9	5.6		

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IN VITRO INFECTION OF BOVINE EPIDERMAL CELLS AND BOVINE SKIN EXPLANTS WITH TREPONEMES

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Introduction

Dermatitis digitalis (DD) is a multifactorial disease of the bovine digit. DD is an important welfare issue and it has a large economic impact. The mechanisms of its pathogenesis are still not completely understood. In addition to typical anaerobic bacteria, a variety of different Treponema phylotypes have been detected as probably involved in the pathogenesis of DD (Choi et al, 1997; Moter et al, 1998). There is a strong need for models enabling studies of virulence factors of DD (Edwards et al, 2003a). The aim of this work was to establish an in vitro model to study the role of Treponema spp. in the pathogenesis of DD, because a suitable in vitro model was not available until now. This paper reports on the successful in vitro infection of cultured epidermal cells and skin explants from the bovine digit with Treponema denticola and Treponema brennaborense.

Material and Methods

Bovine keratinocytes were isolated from the skin at the typical site of DD lesions and from the bulbar region of the claw. Cells were cultivated under standard conditions as described previously (Nebel and Mülling, 2002). Skin explants were obtained from three different sites of the bovine digit. One sample was taken from the dorsal aspect of the digit 5 cm above the claw capsule. Two samples were taken from the plantar aspect, one from the pastern region and the other from the skin just above the claw capsule. All explants were maintained in Dulbecco´s modified Eagle´s medium (Biochrom, Berlin) supplemented with 10 % fetal bovine serum (Sigma, Taufkirchen) and Kanamycin (Biochrom, Berlin) for 12 h to eliminate bacteria present on the surface of the digit. Subsequently, the explants were rinsed thoroughly with Dulbecco´s modified Eagle´s medium without Kanamycin and incubated with Treponema suspension (approximately 5 x 106 treponemes / ml) for 24 h. In all experiments a pair of explants was incubated with T. denticola or T. brennaborense and the incubations were carried out simultaneously. After incubation with the Treponema suspension the explants were fixed in Karnovsky´s solution and embedded in Epon®. Sections were prepared and examined by light and electron microscop. Keratinocytes were cultivated on cover glasses in a mixture of Dulbecco´s modified

Eagle´s medium supplemented with 10 % fetal bovine serum without antibiotics. These keratinocytes were split in two groups and then incubated with OMIZ Pat medium containing either T. denticola or T. brennaborense for up to 96 h. Every 24 h two cover glasses were rinsed twice with phosphate buffered saline and then fixed in 4 % formalin immediately. For visualisation the cover glasses were stained with the DAPI method (1μg/ml) and examined under the fluorescent microscope.

Results

Based on morphological criteria T. brennaborense and T. denticola remained alive under culture conditions for up to 96 h. Most treponemes were still showing their typical spiral shaped morphology after that incubation time. The adhesion of the treponemes to the cultured keratinocytes (Fig.1) was visible at all time points and tended to show an amplified adhesion to the keratinocytes in a time dependent manner. Especially adhesion of T. brennaborense was greater than that of T. denticola. With prolonged incubation cultured cells began to show morphologic damage and some cells detached from the cover glasses.

Investigations of the skin explants at light and electron microscopical level revealed that treponemes were detectable adhering to the surface and between the cells of the outer regions of the epidermis. Furthermore, in some explants treponemes could be detected in deep epidermal layers (Fig.2) by light microscopic examination of semithin sections stained with methylene blue. In addition electron microscopy clearly demonstrated that the treponemes invaded the epidermis via the intercellular spaces of stratum corneum and stratum spinosum.

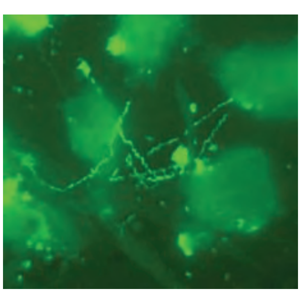

Fig.1: Adhesion of treponemes (arrow) to keratinocytes in vitro

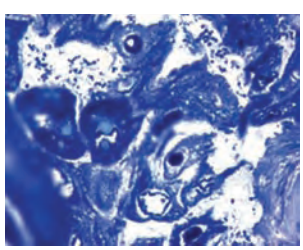

Fig.2: Semithin section of an infected skin explant showing treponemes (arrows) within the intercellular space in deeper layers of stratum spinosum

Discussion

Treponemes survived in cell culture under standard conditions (5 % CO2) for up to 96 h, even though all species have been described as anaerobic, although some may be considered to be microaerophilic. Adhesion of T. denticola to human gingival fibroblasts could be shown under both aerobic and anaerobic conditions (Chan and McLaughlin, 2000).

Several recent reports have implicated spirochetes in the aetiology of bovine DD (Collighan and Woodward, 1997; Moter et al, 1998; Stamm et al, 2002), a major cause of lameness in dairy cattle. Spirochetes of the genus Treponema are among the most predominant organisms visible in DD lesions (Döpfer et al, 1997). Treponemes have been identified in biopsies from DD lesions, they can be found in the stratum spinosum and dermal papillae. Their presence deep in epidermal tissue suggests they are invasive (Choi et al,1997; Moter et al, 1998) which is supported by our in vitro findings. Furthermore, serum samples from diseased animals contain elevated antibody levels to Treponema antigens (Demirkan et al, 1999).

T. denticola has been shown to adhere to basement membrane proteins such as laminin, fibronectin and type IV collagen as well as type I collagen, gelantin and fibrinogen. The binding to laminin was most prominent (Chan and McLaughlin,2000). Edwards et al (2003b) noted that T. denticola cells bound also to keratin.

Fenno and McBride (1998) reviewed cytopathic effects of oral spirochetes. In various in vitro studies of these authors, exposure of epithelial cells to T. denticola caused: visible morphological damage, cell detachment from monolayers and inhibition of proliferation, membrane blebbing, loss of tight intercellular contact and cytoskeletal rearrangement. Our results obtained from the in vitro studies with keratinocytes and explants support these observations. After incubation with treponemes over 96 h keratinocytes showed visible morphological damage and began to loosen from the cover glasses. In further studies with epidermal keratinocytes growing on sliceable membranes we will look for structural damage of the cells and their components by electron microscopy.

In periodontal disease, spirochetes have been found between cells in the junctional epithelium which are normally tightly joined. There is evidence that oral spirochetes invade tissue by migrating through the intercellular tight junctions. Spirochetes were also observed in enlarged intercellular spaces (Fenno and McBride, 1998). Our results support these findings and suggest that treponemes invade the claw tissue via the intercellular spaces of the epidermis. We suggest that the enlargement of the intercellular spaces can permit an increased infection of deeper tissue layers and facilitate the way for infection with other anaerobic bacteria.

The innate immune response is largely blamed for the significant amount of the damage caused bythe release of inflammatory mediators and cytokines. Interactions of vital T. denticola resp. T. pectinovorum with human gingival fibroblasts results in increased secretion of proinflammatory chemokines such as IL-1b, IL-6, Il-8, IL-1 and IFN-g (Nixon et al, 2000). Therefore in a future project we will study differences of the chemokine pattern expressed by the cultured bovine keratinocytes either infected with treponemes or cultivated without treponemes.

So far, our results provide good evidence that the cell culture and explant models introduced in this study will be helpful for further investigations on the pathogenesis of DD and particularly on the mechanisms of tissue invasion. Using these models the molecular mechanisms of adhesion and tissue invasion as well as the tissue response to the infection will be studied.

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IMPACT OF HOUSING TYPE ON PREVALENCE AND SEVERITY OF DIGITAL DERMATITIS

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Introduction

Digital dermatitis is a skin condition of cattle, which usually affects the skin on the bulbs of the heel or between the digits. The lesion causes considerable pain to the cow, resulting in reduced mobility and feeding, with consequent loss of milk production. The condition can persist for months if it is untreated (Peterse 1992). This study was designed to determine the factors affecting the prevalence and severity of digital dermatitis in dairy cows, by appraising the role of the environment in its development.

Materials and Methods

This study was an observational single site study, using the ADAS Bridgets dairy herd, which had 650 Holsteins and endemic digital dermatitis. During winter housing, the hind limbs of all cattle in each of four different houses (a straw yard, two automatically-scraped cubicle yards and one tractor scraped cubicle yard) were examined every three weeks, using a modified Olympus Series 5 borescope, for digital dermatitis. The severity of lesions was scored using a system based on size, depth and colour (Laven and Hunt 2000). Table 1 shows the number of cows examined and the number of lesions observed.

Table 1: Number of cows examined and lesions observed in each of the four housing groups

	Number of cows examined	Number of lesions observed
Tractor-scraped cubicles	183	747
Automatically-scraped cubicles (1)	108	472
Automatically-scraped cubicles (2)	138	454
Straw yard	61	181
Total	490	1854

Results

The prevalence of digital dermatitis in each house is shown for a representative twelve week period in Figure 1, while Table 2 shows the overall mean prevalence for each group (which includes the data collected for longer than the twelve week period shown in Figure 1).

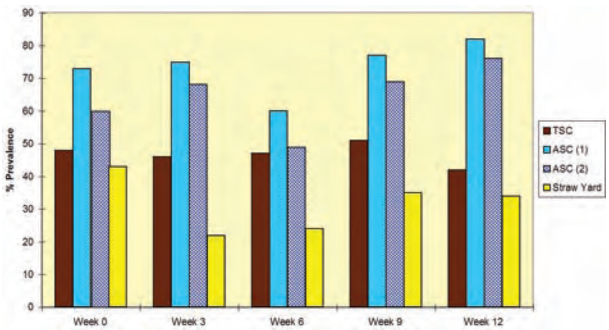

Figure 1: Effect of housing type on the prevalence of digital dermatitis
TSC = Tractor-scraped cubicle. ASC = automatically-scraped cubicles

Table 2: Overall mean prevalence and cumulative prevalence of digital dermatitis

	Mean Prevalence (%)	Cumulative Prevalence (%)
Tractor-scraped	47	67
Automatically-scraped (1)	73	82
Automatically-scraped (2)	64	78
Straw yard	32	

Housing significantly affected the mean and cumulative prevalence of digital dermatitis. Cows on straw yards had a significantly lower prevalence of digital dermatitis than cows in any of the three cubicle yards ($P<0.001$). Cows on the tractor-scraped yard had a significantly lower prevalence of digital dermatitis than cows on automatically scraped cubicles ($P<0.001$). Comparison of the two automatically-scraped cubicles also found a significant difference in prevalence of digital dermatitis. However, the magnitude of this effect was much less ($P=0.03$). There was a significant change with time ($P<0.05$) for all four groups, however there was no discernible pattern to this change.

Mean lesion score

There was no significant change in time of lesion score ($P>0.05$), so data for each house were amalgamated for further analysis. The mean lesion score for the cows in the straw yards (3.1 0.08) was significantly lower than that of any other group of cows ($P<0.01$), while the mean score for the cows on the tractor-scraped cubicles (3.2 0.03) was significantly lower ($P<0.001$) than that for the cows on automatically-scraped cubicles (3.5 0.06 for both yards)

Discussion

As the cows in this study were housed in pre-existing buildings, it is difficult to isolate risk factors and analyse them separately. Nevertheless this study does identify some significant risk factors for digital dermatitis. The main factors identified by this study are housing type (cubicles vs. straw yards) and scraping mode (automatic vs. tractor). Other environmental factors influence digital dermatitis, but this study suggests that their impact is relatively small. This is exemplified by the difference between the two automatically-scraped yards. One was a wooden kennel structure, the other a modern concrete and metal yard, but the effect of these differences was considerably less than the effect of scraping mode.

The cause of the differences in digital dermatitis between houses has not been conclusively identified by this study, but some suggestions can be made. The most likely reasons for the low prevalence on straw are a reduction in exposure to the digital dermatitis agent, and a cleaning effect of the abrasive straw. However, the feet of the cows on the straw yards were of similar cleanliness to those in the cubicles, thus the reduction in exposure is the most likely cause of reduced prevalence.

The causes of the differences in prevalence because of scraping mode are more difficult to assess. The differences between the systems include cubicle design, stocking density, bedding and scraping mode. All three cubicle houses are standard and meet current recommendations and there is no evidence that the design differences had significant behavioural effects. Stocking density was lower in the automatically-scraped cubicles than the tractor-scraped yard, so it is unlikely that this played a significant role in the development of digital dermatitis. The bedding in both of the automatically-scraped cubicles was shavings and lime while that in the tractor-scraped group was straw and lime. Chopped straw may be less prone to combine with slurry and lime than shavings and thus less prone to adhere to the feet. This hypothesis requires further study. However, no differences were observed in the cleanliness of the feet between the groups of cows, thus the major difference was probably the method of scraping. Automatic scraping should clean more thoroughly, but it can result in more slurry around water troughs and connecting passageways, and the collection of pools of mixed slurry in front of the scraper. Although cows tend to avoid these pools, there are times, such as at milking, when the cows may be moved through the slurry, which thus comes into contact with the skin of the foot.

The severity of digital dermatitis was affected by environment in the same order as prevalence was affected. This suggests that severity of digital dermatitis is affected by the same environmental factors as prevalence. The lack of difference in severity between the cows in the two automatically-scraped cubicle yards further confirms that the effects seen here are associated with scraping mode.

Acknowledgements

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INFLUENCE OF FOOTBATHING ON PREVALENCE OF DIGITAL DERMATITIS AFTER INTRODUCTION OF DISEASED ANIMAL INTO HEALTHY DAIRY HERD

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Abstract

On several intensively managed dairy farms, where disinfectant barriers were regularly used, we discovered that after introducing one cow with digital dermatitis, prevalence of digital dermatitis rose enormously. This rise in the number of cases was significantly higher in herds where disinfectant barriers were regularly used.
Bacteriological analyses of samples showed that in all herds we normally found on the heels and interdigital space of the claw Spherophorum necrophorum and Bacteroides nodosus and often also Clostridium perfringens. In occult clinical cases of digital dermatitis we found also Treponema spp., and in most cases two types of spirochetes.
Prevalence of digital dermatitis after introducing a diseased animal was much higher in the herds where disinfectant barriers were regularly used than in herds without footbathing. Where different organic acids or copper sulphate were used incidence was higher than in cases where formaldehyde as disinfectant was used.
Our conclusion is therefore, that maceration of the digital and interdigital skin must be an important factor in establishing digital dermatitis. Furthermore, we think that all infectious elements are not able alone to provoke outbreak of the disease if prior maceration and micro trauma on the skin above claws did not occur.

Introduction

Digital dermatitis was first described by Cheli and Mortellaro in 1974. Espinasse and al described in the Atlas of claw diseases in ruminants also a papillomatous digital dermatitis as a separate disease.For almost 30 years different researchers and scientists try to find reasons for the clinical picture of digital dermatitis. In 1994 Zemljic showed that an important role in the development of the disease was played by different types of Treponemas.Subsequently, groups of researchers found out that digital dermatitis and papillomatous digital dermatitis are histopathologically and immunohistochemically one and the same disease (Zemljic 1996, Read and Walker 1998), which is an important welfare and economic issue in intensively managed dairy production. In the Orlando lameness symposium Zemljic considered that we must reconsider our attitude to the disease and not to try reproduce the disease only with different microorganisms which were proved as potential reason of the clinical picture of the disease. Although we recognise that digital dermatitis is a multifactorial disease with microbial, environmental and management influence, we did not take into account other reasons and causes as equally important and tried to attribute to the microbacteriological part of the story the greatest importance. There were different mostly unsuccessful trials to reproduce the disease with implantation of specific micro-organisms on the healthy and even damaged skin above claws. Now there is a great need for production of the models enabling studies of virulence factors of digital dermatitis (Edwards et al, 2003), which also failed to consider the wide range of potential factors. In the present paper we try to describe simultaneous action of different factors in the development of digital dermatitis, which not only produced the full picture of the clinical picture but also affected prevalence and severity of the disease in dairy cattle.

Material and methods

In three intensively managed dairy herds with average 40 dairy cows and production of more than 8000 l per standard lactation they introduced new disinfectant barriers with novel formula. Before this change they did not have any obvious problems with digital dermatitis, with prevalence less than 10% of diseased animals in the herd. In The farm B and C digital dermatitis after introduction of the disinfectant barriers spread and caused severe problems in management and production with evident losses in the cost benefit analysis. In the farm A the situation was not changed significantly.
After unsuccessful implementation of the different therapies, we made epidemiological analysis firstly and after discovering of the cause of the spreading of the disease, we implemented measures which diminished severity of the clinical signs in the two herds.
In all three farms(A,B,C)the disinfectant barrier was introduced at much the same time. In two farms (B,C) they purchased two cows each with clinical signs of digital dermatitis. In farm B the new animals were introduced about a fortnight before introducing disinfectant barrier and in farm C new animals were introduced in the herd just few days after introducing barriers. In farm A no new animals were introduced.
After discovering which animals were causing the disease spread we took samples for bacteriological and pathohistological analysis. After obtaining the laboratory results we introduced antibiotic therapy and new disinfectant for foot barriers. After three weeks we again made clinical investigation in all three herds to determine changes in prevalence of digital dermatitis.

Results

We made clinical examination of all animals in the all three herds and discovered that in herd C where they did not purchase any new animals, only 2 of 42 productive animals had slight changes in the typical sites on the heel of the hind legs above the coronet.We isolated Spherophorum necrophorum and Bacteroides nodosus, but we did not succeed in demonstrating any Treponemas. Clinical signs were mild to moderate with some pain in the diseased areas.

In farm B with 40 animals, where they purchased two animals 14 days before introducing the disinfectant barrier, we found in 22 animals a typical picture of digital dermatitis, mostly with severe and extensive areas of damage on the heel above the coronet of hind legs. Lameness was generally severe,as were the signs of pain. One animal tended to lie down most of the time. Production drop in this case was according to farm data mostly 80%. Microbiological samples showed presence of Spherophorum necrophorum, Bacteroides nodosus and Clostridium perfringens with two types of Treponema . Pathohistological samples confirmed a severe maceration of the skin layers with ulceration and no tendency to heal.

In farm C with 43 animals, where new animals were introduced a few days after putting in a new disinfectant barrier we found 24 animals with severe changes in hind feet with mostly moderate to severe lameness,and where diseased animal tended to lie down as soon as possible. The bacteriological and pathohistological samples results were similar to the second farm.

On farms B and C we advised quarantine of diseased animals.This was done on farm C but not on B. We also introduced antibiotic topical therapy with tetracyclines twice daily. For all animals we introduced disinfectant barriers with formaldehyde in 3% concentration before entering the milking parlour.

After three weeks we again visited all the farms.The situation was cured on farm C where all measures were carefully carried out.. On farm B prescribed measures were introduced partly. Therapy with topical tetracyclines was not carried out consistently because the owner was afraid of presence of residues in the milk. They used a formaldehyde disinfectant barrier before milking parlour, but the concentration was not controlled efficiently, so in some cases the concentration was substantially higher as prescribed. In some cows we found severe damage of the skin above the coronet, not typical for digital dermatitis. In one case we found exungulation of one claw, another animal had been euthanasied, and prevalence of the disease was still very high (25%).

After consideration we recommended reintroduction of a new disinfectant method on farm C but not on farm B where we reapplied recommendations from three weeks previously with strict control every third day. After another three weeks we found only two animals with clinical signs of the disease, pain was not severe and only very slight lameness was observed. After a second therapy period we reintroduced the new system of disinfection.

Discussion

In this clinical trial we proved that introduction of new animals is a substantial factor in spread of digital dermatitis into a herd. But new animals alone were not enough to spread and develop full picture of the disease. In two farms it was shown that even disinfectant barriers could help in disease spread. It is necessary to have "new" microbial strains which had bigger potential for spread in the new surroundings than " old" ones. It is necessary to have the opportunity for skin maceration above the coronet of the heel. Such maceration softens the skin, makes this skin more acceptable for microtrauma and in a such way typical bacteria also have more potential entrance sites. We consider that this micro trauma offers bacteria enough substrate for survival and multiplication. Due to such processes those animals are not able to follow healthy animals in the production process which certainly also causes a reduction of the immunological response of such organisms. This could be a field for future investigation about development of digital dermatitis. Incidentally, we also showed that only strict adherence to necessary control measures could lead to the abolition of the acute problems with digital dermatitis in the Slovenian dairy herds.

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FIELD EVALUATION OF PROPHYLACTIC AND THERAPEUTIC EFFECTS OF A VACCINE AGAINST (PAPILLOMATOUS) DIGITAL DERMATITIS OF DAIRY CATTLE IN TWO CALIFORNIA DAIRIES

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(Papillomatous) Digital Dermatitis ((P)DD) is a superficial, painful, and contagious bacterial disease causing ulcerative or proliferative lesions on the skin usually at the palmar surface of rear feet near the interdigital space and heels. Although (P)DD is multifactorial and the precise etiology has not been determined, there is compelling evidence that invasive spirochetes play a major role either as primary or secondary pathogens in (P)DD lesions. (P)DD is a significant cause of lameness in dairy cattle resulting in financial loss due to premature culling, decreased milk yield, poor reproductive performance, weight loss, milk discard due to treatment with antibiotics, and treatment and labor costs. The development of an efficacious and cost-effective vaccine is highly desirable. The objective of this study was to determine whether Treponema bacterin provides prophylactic and/or therapeutic effects for controlling (P)DD in cattle.

A total of 420 and 740 Holstein cows were enrolled from two, commercial California dairies with pre-vaccination (P)DD prevalence of 27% and 29% respectively. All lactating cows from each herd were vaccinated with either Treponema bacterin (Novartis Animal Health, Inc.) or placebo, where each enrolled cow received 3 doses 3 weeks apart (according to label instructions). Investigators were blinded as to which cows received vaccine or placebo. Study cows were grouped according to their disease status prior to treatment (visible lesion, no visible lesion) and treatment received (vaccine, placebo). ANOVA showed no significant differences ($P > 0.05$) between vaccinated and non-vaccinated cows in pre-trial lactation group, milk production, and days in milk, which demonstrated that bias in selecting groups was unlikely. After completion of vaccination, all cows were visually examined for evidence of (P)DD monthly for 6 months. The diagnostic technique used was observation with a bright-light and water-jet test in the parlor during milking. Hoof trimmer records from the dairies were also examined to determine if cows were found with (P)DD during hoof trimming that might have been missed in the parlor examinations. A sub-sample of vaccine and placebo cows with no visible lesions were bled pre-vaccinating and at each of the observation periods for ELISA testing for Treponema antigens.

A series of z-tests comparing the monthly (P)DD proportions among cows without visible pretreatment lesions found no significant prophylactic effect (p-values ranging from 0.105 to 0.847). Therapeutic effects of Treponema bacterin among cows with visible pretreatment lesions were also non-significant (p-values ranging from 0.118 to 0.940). Effects were also analyzed by lactation groups. No significant prophylactic effects were observed for 1st lactation cows and for 2nd or later lactation cows with p-values ranging from 0.060 to 0.979 and 0.178 to 0.977 respectively. Likewise, no consistent significant therapeutic effects were observed for 1st lactation cows and for 2nd or later lactation cows with p-values ranging from 0.016 to 0.966 and 0.299 to 0.993 respectively. In one of the herds, the proportion of (P)DD was significantly different ($p = 0.016$) for 1st lactation vaccinates than for placebos during month 1. In this case, however, the difference was due to a significantly higher proportion of (P)DD observed in vaccinates than in placebos.

Data were further analyzed by lactation groups for only those cows present every month. Although no consistent significant effects were observed for cows with no visible lesions for all lactation cows, the (P)DD proportion on 1st lactation vaccinates was significantly lower than placebos. On the other hand, no consistent significant therapeutic effects (cows with visible lesions) were observed for all lactation cows, 1st lactation cows and for 2nd or later lactation cows. A significant difference for the 1st lactation cows was observed but was due to a significantly higher proportion of (P)DD observed on vaccinates than on placebos.

ELISA for serum antibodies to (P)DD-associated Treponema spp. revealed that approximately half of the cows with no visible (P)DD lesions had titers compatible with infection. We are continuing analysis on the serology and observational results.

We conclude that for the two Northern California dairies studied during 6 months, vaccinating the whole lactating herd did not provide significant prophylactic or therapeutic effects. We speculate that the vaccine might prove more efficacious if used on animals prior to exposure to high infection pressure before joining the milking herd.

INVESTIGATION OF THE EFFICACY OF THE KOVEX-FOAM-SYSTEM IN THE DECREASE OF THE INCIDENCE OF DERMATITIS DIGITALIS; DERMATITIS INTERDIGITALIS AND EROSIO UNGULAE

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Introduction

Dermatitis digitalis is a circumscribed superficial ulceration of the skin bordering the coronary margin, with an epithelial border and chronic dermatitis. On the other hand it looks like a circumscribed proliferative, wartlike lesion at the same location1,2. Dermatitis digitalis is a multifactorial disease with an infectious component3. Dermatitis interdigitalis is characterised by an acute or chronic epidermitis in the interdigital cleft. Usually it affects also other regions, i.e. plantar/palmar and dorsal areas of the skin, respectively. Its location and the existing range of germs do not allow a precise differentiation from Dermatitis digitalis4. Changes of the heel horn in correlation with Erosio ungulae are also mentioned in connection with Dermatitis interdigitalis. Some authors describe these changes as separate diseases, whereas others relate to them as symptoms of the aforementioned disease5,6. The generic term "Digital Skin Disorders Syndrome" was suggested4. For a long time one has tried to control these diseases by the means of foot-baths. Even today there are few investigations showing the efficacy of foot baths. Furthermore the use of most common substances (CuSO4, formalin, antibiotics) to heal, soothe and prevent illnesses is not allowed by the German Drug Law (AMG § 2)7. The use of foam based on tensides and peracetic acid before entering the milking stall should remove dirt from the feet after an immersion time of at least 5 minutes. This compact layer of dirt (faeces, liquid manure, slurry) contains microbial populations, which are involved in the described cases of diseases. Moreover the foam is supposed to be disinfectant, due to its low pH value.

Material and Method

Every 6 months a functional hoof-care is performed by professional hoof trimmers at a farm with 70 animals. The animals which are tied up in a longstall on rubber mats, are milked twice daily in a milking stall next door. Before the treatment was commenced the animals were first examined for signs of Dermatitis digitalis, Dermatitis interdigitalis and Erosio ungulae on the hind extremities. 8 weeks after the use of the Kovex-foam-system the animals were re-examined and a further examination was performed again 12 weeks later. Kovex-foam is a hygiene product consisting of an "activator" containing tensides and a "base" with peracetic acid. It is applied to several square meters of an evenly consolidated ground in front of the milking stall. Therefore a mixing unit is installed near the milking stall to blend and foam the two substances. By means of nozzles the prepared foam is applied to the ground. This procedure can be controlled manually. The animals walk through the relatively thick foam which adheres to their hooves, where it helps to remove the dirt. Fresh foam is repeatedly reapplied under supervision. The cattle enter the milking parlour with foam still on their hooves which will break down as it dissolves the soiling.

Study course

The claws of 55 animals were examined before the use of the Kovex-foam-system. After entering the tied-stall on the left and right side of the feeding table the animals were each allocated to a group. Thus 22 of these animals were included in the test group, the other 33 were included in the control group. The control group at the right side of the feeding table is milked first (without foam), followed by the test group standing at the left side of the table (with foam). Before performing the test the cleansed hind extremities were examined for signs of Dermatitis digitalis, Dermatitis interdigitalis and Erosio ungulae and the results were documented. Subsequently the Chi-square and the Fisher`s exact test were used as the statistical method.

During the first 8 weeks the treatment began with a stabilisation phase, where the foam used twice a day in the first week and then suspended in the following week. The 22 animals of the test group were sent through the foam on their way to the milking parlour. Thereafter a new examination of the hind extremities of all animals in both groups was performed. In the following phase, the phase of maintenance, the animals waded through the foam twice daily on 3 consecutive days, then were not treated for 11 days. This change of treatment was to be maintained permanently. After 12 weeks the final assessment of the hind extremities with regards to Erosio ungulae, Dermatitis interdigitalis and Dermatitis digitalis took place.

Results

1. Examination prior to the start of the investigation
   58% of the control group and 50% of the test group were affected with Dermatitis digitalis. 73% of the animals in the control group and 82% of the test group showed changes of Dermatitis interdigitalis. Erosions of the heel horn were found in approximate ly 76% of the control group and 45% of the test group.
2. Examination at the end of the stabilization phase
   48% of the control group were still afflicted with Dermatitis digitalis (26 % of the affected animals healed) and 15% of the test group showed Dermatitis digitalis after the stabilization phase (45 % of the ani mals with signs of Dermatitis digitalis at the first

examination healed). 41% of the control group showed deviations according to Dermatitis interdigi talis. In 25% of the animals within the test group deviations were seen. Now 51% of the control group still showed heel horn erosions, only 30 % of the infected cows had healed. In the test group there were no more affected animals (0 %).

3. Examination after 12 weeks of the phase of mainte nance
   Now 73 % of the control group were afflicted with Dermatitis digitalis, 5 of the healed animals (see above) showed lesions again. In the test group there were 55 % afflicted with the disease, 5 of the healed animals (examination after the stabilization phase) had had a relapse, too. 38 % of the control group still showed Dermatitis interdigitalis, 18 % of the test group were laid up with Dermatitis interdigitalis. Erosions of the heel were found in 65 % of the ani mals in the control group, and in 45 % of the animals within the test group. In each group 5 of the healed cows had a relapse, the others didn't show the char acteristic lesions before.

Evaluation after the stabilization phase

1. Dermatitis digitalis
   With Dermatitis digitalis there was a significant corre lation between the incidence of the disease and the use of the Kovex-foam-system (P = 0.013). There was a relative risk of 2.70 for the animals in the cont rol group not to be completely cured (95% confi dence interval: 0.9922 -7.3569).
2. Dermatitis interdigitalis
   Dermatitis interdigitalis showed no significant effect on the use of the Kovex-foam-system (P = 0.1465).
3. Erosio ungulae
   The incidence of erosio ungulae was significantly dependent on the use of the Kovex-foam-system (P < 0.0016). There was a relative risk of 13.11 for the animals in the control group not to be completely cured (95% confidence interval: 0.8584-200.3933).

Evaluation after the phase of maintenance

After the phase of maintenance there were the following results

There were no more significant differences between the control group and the test group with regard for Dermatitis digitalis, Dermatitis interdigitalis and Erosio ungulae. As to Dermatitis digitalis a trend could be noticed towardsa lower number of animals affected in the test group than in the control group.

Discussion

Due to the significant differences of the hoof condition regarding Dermatitis digitalis, Dermatitits interdigitalis and Erosio ungulae the following can be concluded: The use of dirt-loosening tensides (activator) and the principle to minimize the risk of contamination among the animals by the base (peracetic acid) influences the infectious component3of the mentioned diseases. Especially for combating Dermatitis digitalis and Dermatitis interdigitalis the use of foot-baths is "traditionally" recommended8,9. However, the short reaction time of 30 seconds which obviously can hardly be prolonged with walk-through-baths, does not result in the desired success to stem diseases like Dermatitis interdigitalis10. Compared to the walk-through-baths the contact time of thick foam before the milking process is prolonged and undoubtedly helps to optimise the loosening of the dirt and to reduce the amount of bacteria in the dissolved slurry. The observed restlessness of some animals in the test group during the first week of the therapy with Kovex-foam is likely to be due to a pain reaction. It is assumed that the contact of the foam with a low pH-grade with the lesions is the cause. However, later the animals walked through the carpet of foam without hesitation. Nevertheless the occurrence of the diseases could not totally be eliminated.

Moreover the rate of the diseases increased after the phase of maintenance (3 days with foam twice daily, 11 days without foam). Obviously the regime has to be modified (one week once a day and one week rest or every other day once a day or 4 days once a day every week) to prevent a reccurence of the diseases.

This also emphazises the multifactorial component3. Especially the importance of surface-hygiene on walking- and standing-areas always has to be a main topic. The dissolving of the dirt in the milking parlour for a few minutes cannot alone prevent a new contamination. Dietary factors such as inadequate protein, carbohydrate and raw fibre concentrations as well as a mismanagement and a lack of Cow Comfort also have to be considered.

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TREATMENT OF DIGITAL DERMATITIS WITHOUT USING OF ANTIBIOTICS - A CLINICAL TRIAL

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Abstract

A study was conducted at a high yielding dairy farm to measure the effect of non-antibiotic treatment on digital dermatitis (DD). Functional claw trimming was performed prior to the start of the experiment and 11.8 % of feet (22 of 144) was diagnosed to DD in the herd. Pediline fluid (CID Lines, Belgium), which contains glutaraldehide, copper sulphate, aluminium sulphate, benzalconium chloride, allantoin, non-ionic surfactant, complexing agents and stabilizers, was used for treating the animals. After the first phase of the experiment the occurrence of DD showing clinical symptoms (pain and lameness) was decreased even good epithelisation of the DD lesions were observed. After the second phase all legs were clinically recovered. In conclusion Pediline was strongly effective in the treatment of DD.

Introduction

Lameness in dairy cattle is a major cause of economic losses with approximately 10 to 30% of cows experiencing lameness annually. Lameness was reported as the reason for culling 15% of dairy cows sent to slaughter in the USA in 1996. Lameness is an unacceptable condition which causes severe pain, decreased milk yield, reduced reproductive performance, high culling rates and increased cost of veterinary intervention (Hernandez et al., 2001; Hernandez et al, 2002; Mülling and Lischer, 2002). Average annual losses due to diseases of the bovine digit with clinical symptomps were found US$ 127 per case and 27 US$ per cow present in the herd (Huirne et al, 2002).
Digital dermatitis (DD) is a highly infectious disease that causes painful ulceration to the skin of the foot. The incidence of this disease has increased greatly in recent years. It usually responds to treatment with a range of broad spectrum antibiotics (e.g. lincomycin, oxytetracycline) but commonly recurs within the same lactation (Kofler, 1998; Webster, 2002). Approaches to therapy of DD include surgical excision, foothbaths, topical treatment with various disinfectants or antibiotics, cryosurgery or electrocautery, topical treatment under bandage and systemic antibiotic treatment (Kofler, 1998; Shearer and Amstel, 2002). There are promising studies with using stable-specific vaccines against DD (Szemerédi et al., 2003). Non-antibiotic formulations for treatment of DD may be desirable because of environmental, milk residue and resistance problems of antibiosis.

Materials and methods

The study was conducted in a high yielding dairy farm in Hungary in 2002. The lactational milk yield of the cows was 9000 l on average.
The first sign of DD was the increasing incidence of lame animals in the herd. All the animals were examined and 11.8 % of feet (22 of 144) was diagnosed to DD in the herd. For therapy, Pediline fluid (CID Lines, Belgium) was used. This non-antibiotic formulation contains glutaraldehide, copper sulphate, aluminium sulphate, benzalconium chloride, allantoin, non-ionic surfactant, complexing agents and stabilizers. Pain and size of the lesions were evaluated according to Britt et al. (1999).
In the first phase of the treatment the animals, which had moderate pain and lesions size < 2.5 cm, were functionally claw-trimmed and walked through a footbath with 5% solution of Pediline two times daily during five days. One week later, in the second phase of the treatment, the administration of Pediline was repeated but only once a daily footbath was applied during five days.
In serious cases (7 legs, severe pain and lesions > 2.5 cm) individually treatment was applied by using 20% solution of Pediline sprayed onto the sick surface after trimming and cleaning the claws. These feet were treated once daily during five days and treatment was repeated one week later.
The recovery process was evaluated by detecting the pain and size of the lesions, and pictures were taken by digital camera about each legs on day 0, 3 and 5 during the period of treatment.

Results and discussion

After the first phase of the treatment, the occurrence of the clinical symptoms (pain and lameness) was decreased even good epithelisation of the DD lesions and decreasing lesio size were observed. After the second phase of the experiment all the feet were recovered. This good recovery was observable either after footbathing or topical treatment.
Several results of research were published that show positive effects of non-antibiotic treatments of DD. In their study, Laven and Hunt (2002) compared the efficacy of the footbaths with three non-antibiotic product (copper

sulphate, formalin and peracetic acid) and erythromycin. They found that the lesion score decreased significantly in all four groups but there was no difference between the abtibiotic and non-antibiotic treatment. Gradle et al. (2002), in an uncontrolled clinical trial, also reported that a commercial non-anitibiotic mixture was effective, and Blowey (2000) suggested that formalin footbaths could be suitable treatment for DD.

Most published studies have described the use of non-antibiotic products applied as topical application to individual animals. In these trials copper sulphate, peroxide and cationic agents were used as spray or cream (Hernandez et al., 1999; Shearer and Hernandez, 2000; Moore et al, 2001). Pospicher and Kofler (2002) treated the animals topically with a mixture containing organic acids, essential oils and salts of potassium, zinc, copper and aluminium at low pH. These researchers showed the efficacy of the non-antibiotic products in the topical treatment of DD.

In conclusion, Pediline was effective in the treatment of DD either in footbath or local application in the present uncontrolled field trial.

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TREATMENT OF DIGITAL DERMATITIS IN AUSTRIAN DAIRY COWS WITH THE NON-ANTIBIOTIC PASTE PROTEXIN™ HOOF CARE

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Introduction

The most common methods of treatment of digital dermatitis worldwide include antibiotic and non-antibiotic formulations applied topically with / without bandage, in footbaths or parenteral antibiotics and surgical removal of digital dermatitis lesions especially from the interdigital skin (1-6, 8, 11-18, 20). The most frequent therapy for digital dermatitis in Austrian dairy cows is the topical oxytetracycline spray or other topical antibiotics (11).
Non-antibiotic formulations for treatment of digital dermatitis may be desirable, as any antibiotic treatment can produce antibiotic residue in milk, meat and the soil and progressive resistance development has been reported (7, 19).

Material & Methods

In this study, 47 cows of 8 different dairy farms with loose housing systems and slatted floors showing acute stages of digital dermatitis located on the plantar/palmar or dorsal skin-horn junction of the claws were randomly assigned to 2 groups. Twenty-six cases of digital dermatitis were assigned to each group. Cows with digital dermatitis lesions on the interdigital skin and on atypical sites, cattle with, other disorders causing lameness, and cattle treated with antibiotics and antiinflammatory drugs for other reasons were excluded from this study. The study group with 26 cases of acute digital dermatitis was topically treated with the non-antibiotic paste Protexin Hoof-Care (Probiotics International Ltd., Stoke sub Hamdon, Somerset, UK; study group). Protexin Hoof-Care contains organic acids (formic-, acetic- and propionic acid), salts of copper, aluminium and zinc and essential oils (peppermint, eucalyptus) and has a low pH.
Twenty-six cases of acute digital dermatitis lesions were in the control group and were topically treated with oxytetracycline spray (Terramycin®Aerosol Spray, Pfizer Austria; control group). Pre-treatment and control examinations were documented on 4 occasions, (day 0, 4, 10 and 28) using a standard protocol and a digital camera.
On day 0 the lameness score at rest (0, 1, 2, 3) and at walk (0, 1, 2, 3, 4) was determined. After functional claw trimming the claws and the digital dermatitis lesions were washed and dried with clean tissues. The pain score (0, 1, 2, 3) was determined by digital pressure. The shape, colour, surface morphology and size of the lesions were documented. Protexin Hoof-Care or oxytetracycline spray was applied to the lesion according to the randomisation table. After topical treatment all cows were kept on a dry surface for 30 minutes before returning to the stable.
Statistical analyses were carried out by means of the SAS 8.02, Windows NT Version. The Mc Nemar test was used for comparison of the distribution of changes in scores (lameness, pain) on day 4, 10 and 28 within each group (examination for agreement; $p < 0.05$). The Wilcoxon-Mann-Whitney Rank Sum test ($p > 0.05$) was applied for the unpaired comparison of the scores of the study group and the control group.

Results

In these 47 cows a total of 52 cases of acute stages of digital dermatitis were diagnosed. Forty-eight cases were in the hindfeet and 4 cases on the forefeet with the typical localisation on the plantar/palmar aspect of the claws at the horn-skin junction. In 5 cows digital dermatitis lesions were found in both hindfeet. The mean lesion size was 3.43 x 2.59 cm in diameter.
All acute lesions were highly (17/16) or moderately (9/10) painful on day 0. On day 4 the lesions were black in colour and had a crusty surface. On day 4 the cows showed less pain in both groups: about half of the lesions in each group (13/14) were painless, the others were slightly painful. On day 10 twenty-one cases of the study group and 23 cases of the control group were painless, and on day 28 only 3 cases of the study group and 2 cases of the control group showed a slight painful reaction on palpation.
On day 10 lameness was no longer seen in any cow of the group treated with Protexin Hoof-Care, and only in one cow of the group treated with the oxytetracycline spray. Good epithelializiation of the digital dermatitis lesion was observed on day 10 in 16 cases of the study group and 14 cases of the control group. On day 28 the lameness score was 0 in both groups (Fig. 1).
Our data indicate that both topical applications of the Protexin Hoof-Care paste and oxytetracycline aerosol spray had an identical efficacy for the treatment of digital dermatitis in these dairy cows. No statistical difference ($p > 0.05$) in the examined scores (lameness, pain) could be found between the study and control groups.

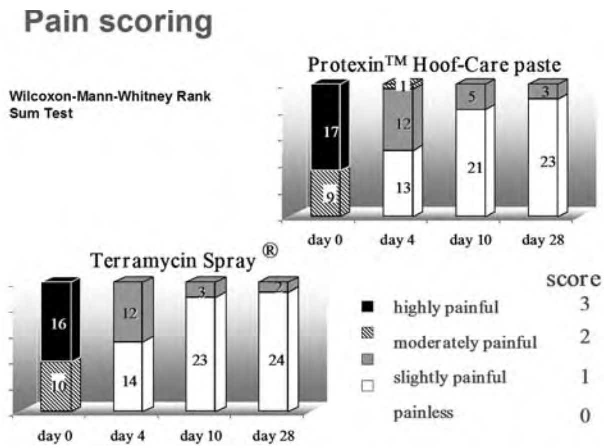

Fig. 1: Development of the pain score of both groups from day 0 to day 28.

Discussion

The convincing results of the non-antibiotic paste Protexin Hoof-Care for the treatment of digital dermatitis, for which spirochaetes are responsible as bacteriologic agents, is caused by the antimicrobial effect of the components of this formulation. These are organic acids and copper- and zinc-sulphate salts which are known for their antiseptic activity, for example in footbaths (1, 5, 12, 15). The low pH of about 2 of this non-antibiotic formulation prevents bacterial growth (5).

The results showed that treatment with either Protexin Hoof-Care paste or oxytetracycline aerosol spray resulted in a significant improvement in digital dermatitis within 4 to 10 days of the first treatment. The examined scores (lameness, pain) showed no statistical difference ($p > 0.05$) between groups.

It has been reported that the site of digital dermatitis lesions can affect the efficacy of topical spray treatment with oxytetracycline in dairy cows (9). Therefore only cows showing lesions on the skin of the heels or the dorsal coronet were selected for this study.

The results in 47 cattle with spontaneous, acute digital dermatitis lesions agree with similar studies from the USA, in which the non-antibiotic formulation Victory® was tested for treatment of digital dermatitis lesions in cattle over a period of 12 to 30 days (1, 13, 17).

The use of a placebo group would have been desirable in this study. Which was carried out under field conditions in private dairy herds and the agreement of the cattle owners for a placebo group could not be obtained. A study on cows of a veterinary teaching hospital herd in Munich showed that the cows with digital dermatitis lesions treated only with the pacebo (water spray) did not show any improvement of the lesion within 10 days (3).

The advantage of Protexin® Hoof-Care paste is that it contains no antibiotics, is not subjected to the medical prescriptions and therefore has no withdrawal time, and cannot leave any antibiotic residue in milk or meat. Formic acid, copper and zinc sulphate are indicated in annex II of the official regulation (EWG) No. 2377/90 of the Council and are permissible in food animals (21).

The results of this study show that Protexin Hoof-Care paste can be recommended to veterinarians and claw trimmers as an interesting and efficient alternative to topical antibiotic treatment for digital dermatitis in dairy cattle.

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