Digital Dermatitis, an Endemic Claw Disease. What Can we do to Control it?

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Introduction

Digital dermatitis (DD), otherwise known as papillomatous digital dermatitis, hairy heel warts, strawberry warts, strawberry foot, raspberry heel, footwarts, digital warts, verrucose dermatitis, or Mortellaro's disease, is a multifactorial disease with infectious, immune and environmental components (AABP, 2006, Read et al., 1998a; Read et al., 1998b). Although it is not fully agreed upon when the condition was first observed, most attribute the first description of this condition to Cheli and Mortellaro (1974) in Italy. Since then, this condition has been reported in intensively managed cattle in all parts of the world with prevalence higher in housed cattle than in grazing cattle, and free stall barns have higher prevalence compared to tie-stalls (Holzhauer et al., 2006; Somers et al., 2005).

Depending on the stage and severity of the lesion, impact of DD on cattle ranges from minor discomfort to severe, debilitating lameness (Frankena et al., 2011). The authors are unaware of any studies that have examined the economic effect of DD in beef cattle. In contrast, a multitude of studies have shown DD in dairy cattle increases the risk of culling, and decreases milk production and fertility (Bruijnis et al., 2010; Cha et al., 2010; Hernandez et al., 2001; Warnick et al., 2001). However, estimates of the impact of DD on dairy cattle performance are variable, which may reflect severity of the lesion afflicting cattle.

Clinical signs and diagnosis

As defined by its name, DD is an acute inflammation of the epidermis or hairy skin (Greenough, 2007) and most commonly affects the palmar/plantar interdigital ridge of the rear feet (AABP, 2006). However, DD lesions can also be found in the interdigital cleft, heel, and dorsal aspect of the coronary band (AABP, 2006). Also, DD lesions can be responsible for secondary infections in sole or hoof wall defects (Gomez et al., 2011). Some have also attributed lesions found in the udder cleft to *Treponema* spp., the suspected causative agent of DD (Evans et al., 2010).

Digital dermatitis lesions range in description from small, circular, red or tan plaques less than 0.5 to 1 cm in diameter to proliferative or dyskeratotic lesions that are more than 6 cm in width with filamentous papillae. Döpfer et al. (1997) introduced five developmental stages of DD:

- **M0,** normal digital skin without signs of DD.
- **M1**, early, small circumscribed red to gray epithelial defects less than 2 cm in diameter that precede the acute stages of DD (M2). In addition, M1 stages can appear between acute episodes of DD lesions or within the margins of a chronic M4 lesion as an intermediate stage.
- **M2**, acute, active ulcerative (bright red) or granulomatous (red-gray) digital skin alteration, >2 cm in diameter, commonly found along the coronary band in addition to around the dew claws, in wall cracks and occasionally as a sole defect.
- **M3,** healing stage within 1 to 2 days after topical therapy, where the acute DD lesion has covered itself with a firm scab-like material
- **M4,** late chronic lesions that may be dyskeratotic (mostly thickened epithelium), proliferative or both. Lesions may be filamentous, scab-like or mass proliferations
- **M4.1**, consisting of a chronic M4 lesion with an early or intermediate M1 lesion within its perimeter, has been reported by Berry et al. (2012).

Generally there is no swelling to slight swelling in the area around the lesion. Experts studying the etiology and pathogenesis of the lesion have also noted a distinct odor.

Afflicted animals will usually show signs of pain in the plantar or palmar regions of the foot (Read and Walker, 1998b). It is commonly observed that cattle with DD lesions will walk on their toes and may shake the affected limb as if in intense pain (Read and Walker, 1998b).

Epidemiology, pathogenesis and etiology

Once introduced into a naïve group of animals, the condition spreads rapidly through the herd with morbidity exceeding 70% (Cramer et al., 2011; Read and Walker, 1994). While it has been most commonly reported in mature dairy cattle, it is not uncommon to see the condition in confined cattle as young as 8 to 10 months of age. Furthermore, while once considered an endemic problem for dairy producers, many feedlot producers are observing DD in their cattle, especially when cattle are housed, of a dairy breed or have been exposed to dairy cattle.

Morbidity rates for cattle can vary throughout the year. Cook (2004) noted that in ten Wisconsin free stall and tie stall housed herds, monthly treatment rates for infectious lesions, primarily DD, were highest January through March and lowest, June through October. In contrast, California researchers (Read and Walker, 1994) noted incidence was highest in the spring and summer months.

The difference in seasonality of peak prevalence for DD may be partially attributed to differences in environmental conditions during the observation periods of the two studies. Wet or muddy conditions have been shown to increase the risk of DD (Rodriguez-Lainz et al., 1996; Wells et al., 1999). Other risk factors for increased prevalence of DD include chemical or physical trauma of the digital skin, purchase of infected cattle and younger age (Rodriguez-Lainz et al., 1996; Wells et al., 1999). Decreased incidence of DD with increased age may be due to increased development of immunity (Blowey et al., 1994; Read and Walker, 1998b), culling of affected animals (Read and Walker, 1998b) or younger animals having thinner skin that is more susceptible to damage than older animals (Gomez et al., 2012).

Researchers have been able to reproduce DD infections in the lower leg of calves by creating an environment of constant moisture and low access to air (Read and Walker, 1998a; Gomez et al., 2012) that results in skin maceration. This environment was created by wrapping the lower legs of calves in cotton, followed by a layer of polyethylene (Saran® wrap), followed by a layer of cotton soaked in tap water, followed by a layer of self-adherent wrap and then placing the foot in a rubber boot that was filled with tap water twice daily for 7 days (Gomez et al., 2012). This environment was designed to mimic that created when the lower leg of the animal is coated in manure creating a moist, low oxygen environment that macerates the skin. Read and Walker (1998a) found that if skin integrity was compromised by trauma or scarification, but access to air was not restricted, cattle did not develop a DD lesion when fresh scrapings from a DD lesion of a clinically affected cow were placed on the compromised skin. Only when the skin was subjected to constant moisture and reduced access to air did cattle develop a DD lesion when scrapings from a DD lesion were placed on the skin.

Read and Walker (1998a) noted that cattle developed DD lesions as early as 14 days after being inoculated with scrapings from DD lesions. Gomez et al. (2012) noted that at 7 to 18 days after inoculation with scrapings from DD lesions, circumscribed skin ulcerations less than 2 cm in diameter became apparent. These lesions were slightly painful and could be classified as a M1 lesion. At approximately 15 to 25 days post infection, the multiple M1 lesions had coalesced into a single painful lesion >2 cm in diameter that was classified as a M2 lesion, characterized by a red color, sharply demarcated limit, and granular moist surface that was prone to bleed when manipulated.

Digital dermatitis lesions are prone to reoccur in 60% of cows, 7 to 15 weeks after being successfully treated (Capion et al., 2012; Berry et al., 1999; Read and Walker, 1994).

High reoccurrence rate may be due to animals being in an environment where they are continually exposed to the causative agent. It may also be due to the suspected causative agent, *Treponema* spp., invading both the epidermis and dermis and topical treatments eliminating organisms present in the epidermis and but not the dermis. Berry et al. (1998; 2012) noted that in lesions treated with lincomycin HCl that appeared to be healed based upon improved lesion score and absence of pain, 56% of these lesions were histologically active or incipient; 1) loss of the epidermal barrier, 2) invasion of the stratum spinosum and papillary dermis by profuse numbers of slender, spiral organisms, and 3) reactive inflammation of invaded epidermis and papillary dermis.

Treponema spp. is a diverse phylogenetic group of spirochetes implicated in human conditions such as syphilis, yaws and periodontal disease (Dashper et al., 2011). The spirochetes, *Treponema phagedaenis, T. vincentii, T. medium, and T. denticola* have been the bacterial agents most commonly implicated as the causative agents of DD (Evans et al., 2009; Strub et al., 2007 and Choi et al., 1997): however, Gomez et al. (2011) noted that tissue homogenates from naturally occurring DD lesions were more effective in inducing lesions than inoculum containing *Treponema* spp. pure culture broth. While *Treponema* spp. have been consistently isolated from DD lesions, evaluations of microbial populations have identified other organisms (Döpfer et al., 1997; Döpfer et al., 2012; Rasmussen et al., 2012; Read et al., 1998; Yano et al., 2010). Diminished virulence of the *Treponema* spp pure culture broth in inducing DD lesions may reflect synergistic relationships between a wide range of microorganisms and may partially explain why cattle on some farms experience far more severe DD lesions than on other farms.

Treatment

In general, topical antibiotics have been effective in treating DD, but represent extra-label use (AABP, 2006) and requires producers to consult with their veterinarian for a prescription, proper labeling and further instructions.

Cleaning the lesion and applying powder or liquid tetracycline under a wrap is a common treatment for DD lesions (Cramer et al., 2011) with the wrap typically removed after 24 to 48 hours. In addition to off-label use of an antibiotic, other concerns with this regimen are it requires moving animals to a chute to apply the antibiotic and wrap and subsequently, someone to go out to the pen to find the animal with the wrap to remove it. If headlocks are not present in the pen and if cattle are not docile enough to allow humans to be in close contact, this requires moving animals to a chute a second time. If wraps are not removed, a moist, low oxygen environment is created predisposing animals to new DD lesions. In extreme cases, improperly applied wraps left on the animal for extended periods of time can cut into the foot or restrict blood flow, creating severe lesions that can permanently debilitate the animal.

In a small study with a limited number of animals, Cramer et al. (2011) found that a treatment regimen of cleaning the lesion and applying a paste consisting of tetracycline hydrochloride 1000 mg/g, propylene glycol and vinegar in a 1:1:1 ratio to DD without a bandage, was slightly less efficacious than applying tetracycline under a wrap.

Another means to control DD, is spraying cattle feet with medicated mixtures containing oxytetracycline (one 102.4 g packet of Terramycin® 343 per 1 gallon of distilled water), or lincomycin (one 16 gram packet of Lincomix®, Soluble Powder per two quarts distilled water; Shearer et al., 2005) where approximately 10 to 20 cc of the medicated spray is applied per foot typically to the heels, toes and any visible lesions. For the first week following initial treatment, all feet should be re-treated once daily for 5 to 7 consecutive days, with continue daily treatment of all cattle with visible lesions, as required. Again, it should be noted that this is extra label use of these products and producers should consult their veterinarian for a prescription, proper labeling and further instructions**.** Antimicrobial residues in milk were within the limits of the regulations when oxytetracycline under a bandage was use for topical treatment of DD (Britt et al., 1999).

The advantage of individually spraying cattle to treat and control DD is that producers think that there is no need to move cattle through a foot bath. In addition, they may not need to run animals through a chute and cost per treatment is less than applying wraps. The disadvantages of individually spraying cattle include the need to remove accumulated debris on feet to allow treatment solution to contact skin lesion and inconsistent application or failure of treatment solutions to adequately contact the infected areas of all feet. Getting treatment solution on desired areas may be especially difficult if headlocks are not used at the feed bunk and if cattle are not docile enough to allow the person applying the solution to get within a reasonable distance of the animal.

Prevention

Footbath Solutions: Footbaths have been widely used to help control infectious claw lesions, such as DD, in lactating dairy cattle. Efficacy of footbaths in preventing infectious lesions is dependent upon a number of factors including footbath solution, frequency of changing solutions, footbath dimensions, footbath placement and animal hygiene.

Effectiveness of a footbath solution in preventing infectious lesions is also dependent upon antimicrobial activity of the solution and the impact of soil load (organic matter) on antimicrobial activity of the solution. For example, chlorine has a broad spectrum of activity against many bacteria (Russell and Keener, 2007); however, it has limited utility in footbath solutions where organic material such as manure reacts with the chlorine, resulting in loss of antimicrobial activity (Russell and Keener, 2007).

***Copper Sulfate*:** Copper sulfate solutions (5 to 10% w/v) are commonly used in footbaths. Copper sulfate is an antibacterial agent that also has a hardening effect on claw horn (Kloosterman, 1997). The bacteriostatic properties of copper sulfate are attributed to Cu^{++} reacting with protein thiol groups in target organisms (Epperson and Midla, 2007). The popularity of copper sulfate footbaths can be attributed to both its relatively low cost per animal treated and widespread perception among producers that it effectively controls infectious lesions. Research has shown that using copper sulfate footbaths decreases both incidence and severity of foot lesions (Laven and Hunt, 2002; Bergsten et al., 2006; Speijers et al., 2010); however, some data suggest that copper sulfate is rapidly neutralized by organic matter (Greenough, 1997).

Concerns with using copper sulfate in footbaths include metal corrosion and disposal of the copper sulfate solution. Assuming that a livestock producer is using a 50-gallon footbath containing a 5% w/v copper sulfate solution, 2X/wk, changed every 200 animal passes, 10.9 lb copper sulfate/animal per year is discarded. Potential concerns with this level of copper disposal include reduced crop yields due to phyto-toxicity and exceeding EPA and state guidelines for copper loading of agricultural land (Rankin, 2004; Thomas, 2001; Ipoplito et al., 2008).

Formalin: Advantages of using a 2 to 5% (v/v) formalin footbath are that it kills bacteria, hardens claw horn, is inexpensive, soluble, bacteria do not develop resistance and formalin eventually breaks down into water and carbon dioxide (Shearer et al., 2005). It is a powerful disinfectant that reacts with the amino, carboxylic, and sulfhydryl groups in proteins, thus changing the conformation and functionality of the bacterial protein (Epperson and Midla, 2007). Research has shown that formalin footbaths reduce incidence and severity of foot lesions (Arkins et al., 1986; Laven and Hunt, 2002) and may retain its antibacterial activity for up to 330 animal passes (Holzhauer et al., 2004).

However, many producers are hesitant to use formalin in footbaths as it is a suspected carcinogen, and must be used in a well-ventilated area with the person mixing the footbath solution wearing adequate hand and eye protection (Shearer et al., 2005). In addition, formalin may not be effective below 50°F and may slow healing of open claw lesions when treated cattle are required to walk-through footbaths (Shearer et al., 2005). Support for these concerns is based upon information and clinical experience demonstrating chemical burns in cattle caused by the use of formalin solutions in excess of 5% (Raven, 1989).

Zinc Sulfate: Anecdotal information suggests some success in controlling DD with the use of footbaths containing 5 to 20% (w/v) zinc sulfate solutions. Zinc sulfate solutions have antibacterial properties, may also act as a hardening agent and are relatively inexpensive to use in footbaths however has not been widely accepted because of difficulty in dissolving most sources of zinc sulfate in water. Furthermore, controlled research on zinc sulfate footbaths for control of infectious foot skin lesions in cattle has not been conducted. Poor solubility of zinc sulfate has prompted several companies to launch soluble zinc products for footbaths (Cook, 2007). The most notable of these products is a liquid zinc chloride product called Hoof Zink®. Field reports indicate Hoof Zink appears to be effective in preventing infectious claw lesions (Cook, 2007).

One advantage of using zinc based chemicals in footbaths is that zinc is commonly included in corn fertilization programs. Depending upon zinc content of soil, soil type and application method, up to 10 lb of zinc will be applied per acre (Shapiro et al., 2003). However, even livestock producers including zinc in corn fertilization programs, should be cautioned that if they are using a 50-gallon footbath containing 10% zinc sulfate solution, 2X/wk, changed every 200 animals, 8.8 lb zinc/animal per year will be dumped into manure and ultimately onto crop fields. According to EPA Standard 503, the cumulative loading limit for zinc is 2499 lbs/acre at an annual application limit of 125 lbs/acre (EPA, 1999).

Antibiotics: Various antibiotics have been used in footbaths for cattle including solutions of 0.1% oxytetracycline and 0.01% lincomycin (Shearer et al., 2005); however, effectiveness of antibiotics in footbaths is suspect with rapid neutralization of the antibiotic in footbath solutions being the primary problem. Potential users are also reminded that such application represents extra-label use of antibiotics and that use of antibiotics in footbaths is costly and because of water quality issues (high mineral content, Ca and Mg carbonates) may require the use of distilled water for mixing (Shearer et al., 2005). Finally, limited evidence suggests that there is a potential for bacteria to develop resistance to the antibiotics and the recurrence rates are the same compared to other footbathing agents.

Commercial Products: Table 1 includes a sampling of several products marketed for use in footbaths. This list is by no means complete nor is it an endorsement of any of these products. While there are many commercial footbath products on the market, research with these products is limited.

Table 1. Some common commercial footbath products[a].

Product	Active Ingredient	Instructions	Reduction in Cu/Zn Disposal[b]	Research
Healthy Foot®, low pH Cu solution (SSI Corporation)	Cu 0.52% Zn 0.19%	0.5 gal per 50 gal H_2O + 5-7 lb $CuSO_4$ or $ZnSO_4$ Use daily for 5 d; Change every 150 animals	66.0% reduction in Cu disposal	Not available on footbath application
Rotational Zn®, (SSI Corporation)	Zn 1.56%	0.5 gal per 49.5 gal H_2O + 5-7 lb $ZnSO_4$ Change every 150 animals Use in rotation with other products	74.8% reduction in Zn disposal	Not available on footbath application
HoofPro+®, acidified ionized Cu solution (SSI Corporation)	Cu 0.79%	0.5 gal with 49.5 gal H_2O + 5-7 lb $CuSO_4$ Change every 150 animals Use 4 to 6X/wk	65.5% reduction in Cu disposal	Not available on footbath application
Double Action®, (WestAgro, Inc.)	Quaternary ammonium compound	1 gal with 49 gal H_2O Change every 200 animals Lesion prevalence: High – 2X/d for 7 d Medium – 2X/d for 5 d Low – 2X/d for 3 d Most Commonly Used Only 1X/d	100% reduction in Cu and Zn disposal	Yes, but not peer-reviewed published
Hoof Zink (GARCO)	Zn 28%	1.32 gal with 50 gal H_2O	23% reduction in Zn disposal	Yes, but not peer-reviewed published
PediCuRx Trifusion (GEA)	~9% Cu-quaternary ammonium-peroxide complex	0.5 gal with 49.5 gal H_2O + 12 lb $CuSO_4$ or $ZnSO_4$ Change every 150-250 animals, depending on soil load	36 and 43% reduction in Cu and Zn disposal	Yes, but not peer-reviewed published
PediCuRx Complete (GEA)	~18% Cu-quaternary ammonium-peroxide complex	1 gal with 49 gal H_2O Change every 150-250 animals, depending on soil load Undiluted product can also be applied topically	71% reduction in Zn or Cu disposal	Yes, but not peer-reviewed published
PediCuRx Prevent A (GEA)	Quaternary ammonium compound	1 gal with 49 gal H_2O Use in rotation with Prevent C and Z, change every 150-250 animals, depending on soil load	100% reduction in Zn or Cu disposal	Not available on footbath application
PediCuRx Prevent C (GEA)	Cu ~20%	1 gal with 49 gal H_2O Use in rotation with Prevent A and Z, change every 150-250 animals, depending on soil load	63% reduction in Cu disposal	Not available on footbath application
PediCuRx Prevent Z (GEA)	Zn ~20%	1 gal with 49 gal H_2O Use in rotation with Prevent A and C, change every 150-250 animals, depending on soil load	72% reduction in Zn disposal	Not available on footbath application

[a] This list is not a complete listing of footbath products marketed in the United States nor is it intended to be an endorsement of any product listed in the table.

[b] Assumes an 12 ft. x 2 ft. footbath filled with 5 inches of solution, changed every 150 animal passes; compared to a 5% copper sulfate or a 5% zinc sulfate footbath solution.

Field trials on two commercial dairy herds in the United States found that using a 5% Double Action® footbath solution for 3 to 12 months reduced incidence of DD by 57 to 80%, when compared with disease prevalence at the start of the study (Seymour et al., 2002). In contrast, using a 5% Double Action footbath solution on a commercial dairy in Washington over a 12 week period did not reduce prevalence of DD (Janowicz et al., 2004). It should be noted that initial prevalence of DD was considerably lower in the Janowicz et al. (2004) study as compared with initial prevalence rate of DD in the Seymour et al. (2002) studies (5% vs. 15 and 23%).

In recent years, researchers have employed split footbaths to test efficacy of various products. This technique allows researchers to literally do side by side comparisons of different footbath solutions with the down side being that the researcher is only able to compare two footbath solutions at the same time.

Research using the split-footbath system on two commercial Midwestern dairy herds found that a 2.5% copper sulfate footbath with PediCuRx TriFusion, 5d/wk for four consecutive weeks, resulted in a similar reduction in pain scores from DD as that observed with a 5% copper sulfate solution (Gradle et al., 2006). British research using these split-footbaths on a commercial dairy herd found that using 2% Double Action footbath, 7X/wk for 6 months resulted in a similar incidence rate of DD and heel erosion as compared with a 5% formalin footbath (Janowicz et al., 2006).

Danish researchers employed split-footbaths to evaluate efficacy of 3 different commercial products containing either glutaraldehyde, organic acids or quaternary ammonium on 12 dairies (Thomsen et al., 2008). The researchers found that none of the footbath products were effective in reducing prevalence of active DD lesions in comparison to no footbath. In this study, cattle walked through a 230 cm long footbath twice a day, 2 d/wk for 8 weeks and solution was changed every 100 cows.

Using split-footbaths on a commercial dairy, Cornell researchers found that a commercial footbath product containing phenoxyethanol was as effective as a 10% copper sulfate solution and more effective than a 5% formalin solution (Teixeira et al., 2010). Cows went through a 1 meter long footbath, twice a week and solution was changed every 45 cows.

It should be noted that while research on the efficacy of the products listed in Table 1 is limited, using these products in place of copper sulfate will reduce copper disposal rates by 36% or more. In addition to the concerns regarding the amount of metals discarded per animal per year, another concern with footbaths is cost. Using a footbath 2X/wk can cost $9 or more per animal per year with some dairy producers reporting spending more than $50/cow per year on footbath products.

Improving Footbath Efficacy: Efficacy of footbath solutions is dependent upon proper strength of solution and proper management and use. For instance, Speijers et al. (2010) found that a 5% copper sulfate footbath, used 4x/week or every 2 weeks was more efficacious in preventing DD than 2% copper sulfate footbath used 4x/week or every 2 weeks. Furthermore, running animals through a 5% copper sulfate footbath each week when prevalence of DD was high was the most effective.

Feet should be as clean as possible prior to the footbath to maximize the amount of skin and horn that contact the treatment solution. If a manure cast covers the foot on a number of animals in the herd, producers may want to consider running cattle through a 1% liquid hand soap or salt solution several times a week on alternate days to running them through the treatment bath solution (Dairyland Initiative Website, 2013).

Effect of prebaths on efficacy of footbaths is questionable. It has been a commonly held notion that while prebaths helped remove some of the debris on feet they also stimulated animals to defecate prior to the treatment bath, thus keeping the treatment bath cleaner. However Wisconsin researchers found that when a prebath was used in conjunction with a treatment bath, more cows defecated in the treatment bath than the wash bath (Dairyland Initiative Website, 2013). Other concerns with using a prebath include increased liquid to dispose, potential for prebath solution to spill into the treatment bath diluting the treatment solution and limited effectiveness in removing manure from feet.

Configurations and management of footbaths used in the livestock industry vary widely. In a survey of 65 freestall-housed dairy herds in five different countries, Cook et al. (2012) found the average footbath measured 7.4 ft long (range 5.2 to 14.9 ft) by 3.4 ft wide (range 1.0 to 11.5 ft), and was filled to a depth of 4.3 inches (range 2 to 7 inches) with a volume of 50 gallons (range 21 to 374 gallons). Producers used footbaths 1 to 4 times per day for 1–7 d/wk, with between 80 and 3,000 cows passing through the bath between chemical changes.

One factor affecting efficacy of footbath solutions in controlling infectious claw lesions is contact time. While measuring the actual amount of time the foot spends in the foot bath solution can be difficult due to the rapid speed animals move through the bath, foot immersions in solution can give an estimate of contact time. Cook et al. (2012) found that in order to get at least 2 immersions per foot per cow pass, 95% of the time, footbaths should be at least 10 to 12 feet long. In order to minimize the amount of solution needed to charge the system, footbaths should be 1.5 to 2 feet wide with sloped solid sidewalls so cattle must step in the footbath and cannot step around the footbath (Cook et al., 2012). This width works as long as the footbath is 3 feet wide at 3 feet above the floor when mature dairy cattle are run through the footbath. Width 3 feet above the ground can be reduced to less than 3 feet if one is running animals smaller than 1400 lbs through the bath. Footbaths should be filled with a minimum of 4 to 6 inches of solution, ensuring that the skin of the interdigital space comes in contact with the footbath solution (Raven, 1989). Producers should be cognizant that the depth of solution in a footbath can vary if located on a sloped floor. To insure adequate contact time with the interdigital skin, solution depth should be at least 4 to 6 inches for a least 10 to 12 feet of the bath.

Animals should have access to a clean area for 1 to 2 hours after passing through the footbath to maximize effectiveness of treatment solution. Also, if feet are overgrown, producers may want to consider having feet trimmed by a trained hoof trimmer to ensure horn overgrowth does not restrict footbath solution from contacting the interdigital skin. Establishment and/or maintenance of proper claw angle will help improve heel height and may also reduce potential for exposure of the heel region to manure and the infectious organisms.

Cook et al. (2012) noted that “Activity and effectiveness varies with the different antibacterial agent used, the time and temperature that they are used, and the degree of manure contamination and susceptibility of the agent to fecal deactivation. Until that information is available, producers should titrate the number of animal passes against the pen prevalence of reported infectious hoof disease to achieve least cost prevention. If the last pen of cows through the bath has a significantly greater prevalence of infection than the rest of the herd, then the number of cow passes between solution changes should be reduced.”

Cook (2007) proposed using hygiene scores to determine frequency of footbath use. Animals are scored on a scale of 1 to 4: Score 1 = clean, little or no manure contamination of lower limb; Score 2 = slightly dirty where lower limb is lightly splashed with manure (more hair showing than manure); Score 3 = moderately dirty, where there are distinct plaques of manure on the foot progressing up the limb (more manure showing than hair); and Score 4 = very dirty, confluent plaques of caked on manure on foot and higher up the lower limb (no hair showing). If greater than 75% of the animals score a 3 or 4, footbaths should be used

7X/wk, 51-75% score a 3 or 4, footbaths should be used 5X/wk; 25 – 50% score a 3 or 4, footbaths should be used 2X/wk and if less than 25% of the herd scores a 3 or 4, footbaths should be used as required to control infectious lesions.

For cattle that are not going through a milking parlor 2 or 3 times a day, 7 days a week, the above recommendations may be difficult to follow. For effective control of DD using a footbath, feet should be kept as clean as possible to maximize contact between skin and footbath solution and footbaths should be run at least once a week. This is due to cattle developing M1 lesions within 7 days after being exposed to the suspected causative agent for DD (Gomez et al., 2012).

Currently, it is not known if the optimal interval for changing footbath solutions is dependent upon time, number of cattle passes or both. It is currently recommended that footbath solutions be changed every 150 to 200 animals to maximize effectiveness of treatment solution. The optimal interval for changing footbath solutions may vary from farm to farm depending upon cleanliness of animals, footbath size and footbath solution. Developing a quick, on farm test, may allow some producers to reduce the frequency of changing footbath solutions, while effectively controlling infectious lesions. In addition, one should also use foot health records to assess the efficacy of footbath protocols by monitoring the development of chronic-subclinical DD lesions.

Stand-In Footbaths: Another alternative to walk-through footbaths is stand-in-footbaths. Stand-in footbaths are used to treat animals on an individual basis and are targeted primarily at animals chronically affected with infectious lesions (Raven, 1989). Cattle stand in the footbath solution for 30 to 60 minutes in order to thoroughly disinfect the interdigital skin and heel bulb. The stand-in footbath appears to be most effective for cattle in which claw shape or horn overgrowth limits the amount of footbath solution that comes in contact with the interdigital skin (Raven, 1989).

Use of stand-in footbaths allow the producer to intensify treatment of chronically infected cattle, while reducing the frequency of use of walk-through footbaths for the remainder of the herd, resulting in reduced cost for footbath solutions and reduced concerns regarding disposal of spent footbath solutions. However, in order to effectively utilize a stand-in footbath, producers must first have accurate records on claw lesions to identify cattle chronically afflicted with infectious lesions and a relatively easy and efficient method of separating chronically infected cattle from herd mates and moving these animals to the stand-in footbath. Appropriate hoof trimming can also minimize the need for stand-in footbaths.

Vaccines: Currently there is not a vaccine that is being marketed to help control DD. A few years back, a *Treponema* spp bacterin vaccine was developed in the US and early field studies were encouraging. However, in a blind field study using 1160 cows on two commercial dairies in California, Ertze et al. (2006) found that vaccine was no more effective than the placebo and the vaccine was removed from the market. Due to several different *Treponema* spp (Choi et al., 1997; Evans et al., 2009, Strub et al., 2007; Yano et al., 2009) and possibly organisms outside the *Treponema* spp. being associated with DD (Döpfer et al., 1997; Read et al., 1998; Yano et al., 2010), developing an efficacious vaccine appears to be difficult (Berry, 2009).

Summary

Controlling DD on dairy operations has proven difficult and remains one of the major claw lesions afflicting dairy cattle. Controlling DD in feedlots appears to be even more perplexing since feedlots do not move, handle or restrain cattle on a daily basis making the use of footbath and foot spray programs cumbersome and time consuming to implement. Further compounding the problem is that cattle in feedlots are not self-propagating, requiring continual movement of cattle from a multitude of sources into the feedlot. The increasing incidence of DD in many feedlots suggests that it is not a matter of if cattle in a particular feedlot will be exposed to DD but when.

If a feedlot does not yet have DD, one thing producers can do to minimize exposure include running cattle through a 5% copper sulfate several times prior to comingling new arrivals with other cattle. Also, as producers look to build new facilities or remodel existing facilities, accommodations should be made to allow easy and frequent footbathing of cattle in addition to quarantine measures for new arrivals. Another management practice that can help reduce prevalence of DD is to keep pens as dry and clean as possible to minimize manure buildup on feet of cattle. Finally, there has been discussion in the field about several feed additives that may help control DD however, controlled research studies on the efficacy of these products currently remains very limited.

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