

Lameness in Dairy Cattle

¹J.K. Shearer DVM, MS., Dairy Extension Veterinarian
University of Florida

²S. Van Amstel DVM, MS., Associate Professor
University of Tennessee

Introduction

Bovine lameness represents a major health problem for the dairy industry. In problem herds where incidence is high lameness accounts for tremendous economic loss. Claw disorders associated with chronic subclinical laminitis are primary causes of lameness in most herds. These are complicated by heat stress, housing and other management considerations which are significant contributors to lameness in dairy cattle.

Infectious skin disorders of the foot include footrot, interdigital dermatitis, and digital dermatitis. These conditions are responsive to systemic or topical antibiotic therapy. Regardless of cause, early detection and prompt treatment minimizes losses, improves outcome, and reduces animal suffering. Neglect not only increases losses but raises important animal welfare concerns.

Economic Loss Associated with Lameness

The economic loss incurred as a result of disease arises primarily from the consequences of disease and not the cost of treatment. British researchers estimated that sole ulcers were responsible for the greatest economic loss (\$627/case, converted to US dollars assuming the value of the British pound at 1.6 to 1 US dollars), followed by digital diseases which accounted for losses of \$257/case. Digital dermatitis and foot rot accounted for smaller, but significant losses at \$128/case. Lower milk yields, reduced reproductive performance, higher involuntary culling rates, discarded milk, and the additional management effort required to care for lame cows accounted for the majority of economic loss.

Guard reports similar but slightly lower rates of economic loss based on clinical observation and records of lameness in New York dairy herds. Based on an incidence rate of 30 cases/100 cows/year, a fatality rate of 2%, an increase in days open of 28 days, and costs for treatment and additional labor of \$23/case, he estimated a cost of \$9000/100 cows/year. Cost per clinical case in Guard's example is \$300/lame cow, or \$90/cow in the herd. Clearly, these figures indicate that lameness is one of the most costly health problems affecting dairy cattle.

The Biomechanics of Weight-bearing

Ninety percent or more of lameness in dairy cattle involves the foot. Of that involving the foot, most involves rear feet, particularly the lateral claw. This pattern of lameness is indicative of the fact that more than just nutrition and feeding management errors are responsible for lameness disorders. At least one plausible explanation exists from studies on weight-bearing in cattle. The biomechanics of weight-bearing in cattle are well described in a book entitled "Cattle Footcare and Claw Trimming" by E. Toussaint Raven from the Netherlands. Following years of study and observation, his insight on weight-bearing and the likely effect of housing conditions (hard floors) on foot problems has added much to our current

understanding of lameness, particularly as it relates to hoof overgrowth and weight-bearing, laminitis and claw disease.

The hind legs of the cow are connected to the pelvis through a ball-and-socket joint. This creates a fairly rigid skeletal structure for support of the rear quarters and legs of the cow. Viewing this anatomical arrangement from the rear, in an animal standing squarely on its feet, one can visualize weight distribution as being essentially equal over all 4 claws of the rear feet. However, during movement the distribution of weight within and between claws changes. Studies by Raven show these changes in distribution of weight to be greatest for outside claws. Despite movement, load-bearing on the inside claws is more even. Outside claws automatically and continuously correct for ever-changing weight load. However, it's this circumstance of ever-changing weight distribution that is believed to be the major reason for accelerated hoof growth and a higher incidence of claw disorders involving the outside claw.

The situation for front feet is quite different. First of all, there is more flexibility in the anatomical arrangement of the skeleton and soft tissues of the shoulder. Front legs are not connected to the upper body through a ball-and-socket joint. Instead, front legs are connected to the torso by tendons and ligaments that tend to cushion the effects of variable weight distribution between the claws. As a result the bio-mechanical forces associated with variable weight distribution are less pronounced in front feet and disorders leading to lameness less frequent. However, when lesions do occur they are more commonly associated with the inside claw.

Confinement on concrete or other hard surfaces enhance the physical effects of excessive load-bearing on feet, whereas housing on earthen surfaces dampens these effects. The practical significance of which is the observation of cattle (especially heifers) moved from pasture to confinement that experience lameness due to a physical/mechanical form of laminitis. These physical effects are further complicated by the fact that the unyielding nature of hard-flooring surfaces tends to irritate the corium and accelerate hoof growth. Excessive hoof growth (particularly of the outside claw of rear feet) leads to overgrowth and eventually overloading of the affected claws. The end result is a greater likelihood of developing claw disease.

Confinement on hard surfaces is sufficient alone to cause a mechanical form of laminitis that, subsequent to overgrowth and overloading of the claw alone, could lead to claw disease. However, add to this complications incurred from metabolic or systemic disease and the severity (as well as incidence) of laminitis and claw disease escalates dramatically.

Laminitis (Founder) and its Relationship to Claw Disease

Simply stated, laminitis is an aseptic inflammation of the sensitive lamina (corium) of the foot. Since more than just the laminar portion of the corium is involved, coriosis is considered by some a more accurate term. To many, however, laminitis is founder.

The pathogenesis of laminitis is believed to be associated with a disturbance in the micro-circulation of blood in the corium which leads to breakdown of the dermal-epidermal junction between the hoof and the third phalanx (P_3 , the bone within the claw). Rumen acidosis is considered to be a major predisposing cause of laminitis and presumably mediates its destructive effects through various vasoactive substances

released in coincidence with the development of rumen acidosis. These vasoactive substances initiate a cascade of events in the vasculature (blood vessels) of the corium including hyperemia (increased blood flow), thrombosis (clotting), ischemia (loss of blood supply), hypoxia (lack of oxygen), and arterio-venous shunting (shunts which direct the flow of blood directly from artery to vein). The end result is edema (swelling), hemorrhage (bleeding), and necrosis (tissue death) of corium tissues.

By virtue of its anatomical location between the hoof shoe and P_3 the corium is particularly vulnerable to inflammatory insult. Any increase in size of the corium due to fluid accumulation (blood and lymph) will increase pressure, pain, and tissue damage. Bound on one side by the hoof wall and the other by P_3 inflammation of corium tissues often leads to swelling at the coronary band.

Destruction of the dermal-epidermal junction has particular consequences as it permits laminar separation. As the laminae separate P_3 begins to "sink" within the hoof horn shoe. The result is compression of the corium between P_3 and sole which sets the stage for the development of sole ulcers. In some cases this " P_3 sinking phenomenon" involves severe rotation of the toe of the P_3 downward toward the sole. If compression of the corium by the toe is severe enough a toe ulcer may develop. If, on the other hand, the sinking of P_3 is such that the rear portion sinks furthest, compression and thus sole ulcer development will most likely develop in the area of the heel-sole junction (known by some as the "typical site" or the site most commonly associated with the development of sole ulcers).

Sole Ulcer

A sole ulcer is described as a circumscribed loss of the horny sole which exposes the corium. Sole ulcers tend to be one of the most debilitating of lameness conditions affecting dairy cattle. Appearance of the lesion will vary according to it's maturity. Early ulcers may appear as nothing more than a circumscribed area of fresh tissue that may be uncovered in the process of hoof trimming. More mature or long-standing sole ulcers may be covered initially by rough, irregular horn tissue that when pared away exposes granulation tissue which bleeds freely if damaged.

As indicated previously, laminitis is thought to be a major predisposing cause of sole ulcers. The combination of excessive hoof horn formation, displacement of P_3 , the production of softer solar horn, and the accelerated growth of hoof horn on the anterior and abaxial hoof walls predispose the lateral claw to excessive loading, wear, and weight-bearing at the "typical site". The additional strain and pressure applied to the heel/sole region (or toe in the case of toe ulcers) exacerbates dysfunction of the underlying corium and leads to development of the lesion. Treatment requires removal of the necrotic (dead or decaying) horn tissue followed by elevation of the affected claw with a footblock attached to the unaffected claw. All healthy horn tissue should be left in place.

Regular hoof trimming is an important factor in lowering the incidence of sole ulcers. Periodic trimming maintains appropriate weight-bearing on all claws and reduces the potential for excessive claw-loading and sole ulcer development.

White Line Disease

Areas of hemorrhage and necrosis of the corium are often most noticeable and severe in the white

line region of the sole. This corresponds to the weight-bearing region of the claw. Because it is an active area of hoof formation it is highly vascular, and a frequent site for hemorrhage during bouts of laminitis. These areas of hemorrhage are not visible during the acute stage of laminitis. Instead, as the sole grows downward from the overlying solar corium these hemorrhages gradually become visible on the surface of the sole over a period of weeks. At this point they become useful as indicators of disease of the corium (subclinical laminitis).

Another outcome of veterinary significance associated with laminar necrosis is the formation of subsolar abscesses (otherwise known as white line disease). Some of these abscesses are sterile but nonetheless troublesome as they cause acute lameness in affected animals. However, sole abscesses from white line disease tend to occur at higher incidences in animals suffering laminitis via another mechanism - penetration of the white line by foreign material from the environment. There are a couple of reasons for this: 1) dermal-epidermal separation and distorted claw growth which results in widening of the white line, and 2) hoof horn formed by the diseased corium is soft and prone to separation which makes it subject more subject to wear and penetration by foreign material from the environment. As a consequence, the incidence of white line disease increases in herds suffering laminitis.

Regardless of how the abscess develops, it is treated by paring and drainage. For abscesses which develop as a result of penetration through the white line or sole, establishing drainage through the original site of the contaminant's entry is the desired approach when possible. The site of entry can usually be visualized as a dark area packed with extraneous debris on the surface of the sole. Visibility of these is often improved following cleaning and/or paring away of the superficial layers of the solar horn. Once the entry site is located careful paring out of the tract leading to the abscess is required until drainage is accomplished. Care should be taken to establish drainage, however minimize peripheral damage. The hoof wall adjacent to the abscessed area should be pared away so that weight-bearing is minimized at this site. Furthermore, removal of the wall adjacent to the abscess prevents extraneous material from being packed into the solar defect created by paring to establish drainage. All undermined and loose horn associated with the abscess should be removed. Many animals will show immediate improvement, whereas others in which the abscess was more extensive may take several days to improve. There is no need for antibiotic therapy unless the infection extends to deeper tissues of the foot as evidenced by swelling and severe lameness.

Sole abscesses are extremely painful. For severe cases, pain can be alleviated through the application of a foot block to the unaffected claw of the affected foot as described for treatment of sole ulcers. Elevation of the damaged claw suspends weight-bearing, reduces discomfort, and promotes recovery. Blocks will eventually wear off after a period of 2-4 weeks or 2-3 months depending upon housing conditions.

Foot Trimming: Why, When, and How

Why?

Hoof growth is relatively slow at about 5 mm per month. Shape of the hoof is a product of the rate of growth versus the rate of wear. Overgrowth is more or less a natural consequence of feeding and

housing conditions common to intensive dairy production. The effect of hoof overgrowth is overloading, particularly of the lateral claws of rear and the medial claws of front feet.

Overgrowth is manifested primarily at the toe. Hoof horn is harder, growth is more rapid, and the rate of wear is less at the toe. In contrast, hoof horn is softer, growth is slower, and the rate of wear (weight-bearing is greater) is more rapid at the heel. The end result is a lengthening and raising of the toe with a corresponding lowering of the heel. The angle of the front wall may be altered from a normal of 45° to 30° or less. Overgrowth also occurs on the sole. Humans develop calluses on the weight-bearing areas of their feet (balls of the foot and heel). Cows don't develop calluses; instead they produce more horn on the soles of the weight-bearing claws (i.e. lateral claw of rear and medial claw of front feet).

The dynamics of hoof growth and overgrowth are even more exaggerated for cows that have experienced laminitis or for those housed on concrete or other hard flooring surface. The purpose of foot trimming is to re-establish appropriate weight-bearing within and between the claws of all 4 feet. In so doing, trimming reestablishes proper function.

When?

Most cows will benefit from trimming 1-2 times per year. There are a few cows which may require hoof trimming more than twice per year. The majority of operations trim cows one time per year at dry-off. Considering the foregoing discussion of the effects of feeding, housing, and laminitis on hoof overgrowth, one could justify trimming (or at least an evaluation to determine the need for trimming) at mid-lactation. It is obviously more risky to trim cows at mid-lactation, however trimming at dry-off only assures that most cows will go well beyond 1 year before seeing the trimming chute. Depending upon housing conditions and the prevalence of laminitis, problems with hoof overgrowth and claw disease are near certain for some herds which trim only at dry-off.

How?

The fundamentals of hoof trimming are well described by Raven in his book, "Cattle Footcare and Claw Trimming". Readers are advised to consult this book for a more in-depth review of this topic. For the purposes of this discussion we have chosen to outline the procedure for trimming feet into 6 basic steps.

The objectives of preventative hoof (claw) trimming are:

Correction of the relative overgrowth that leads to overburdening of the claw (overgrowth is most significant for the outside claw of rear feet and the inside claw of front feet).

1. Restoration of the appropriate weight-bearing surface within each claw.
2. Correction of claw lesions at an early stage.

The following 6-Step work plan for trimming feet is recommended:

STEP 1

Judge the length of the claws. Since the inner hind claw represents the more normal claw, this claw is used as a model for the more abnormal outer claw. The front wall of the medial (inner) claw should be 3 inches long (from the skin-horn junction to the tip of the toe). This length of 3 inches (7.5 cm) is taken as the correct front wall length for the average Holstein-Friesian cow. Thickness of the sole should be a minimum of a 1/4 inch. Spare as much of the heel on the medial claw as possible.

Reduce the length of the inner claw to this required length. Next the bearing surface (sole and wall but not the heel) is “stabilized” on the inner hind claw. In other words, the bearing surface of the toe and wall is pared flat so that it will be at right angles to the long axis of the shin (cannon) bone in the standing position. This will ensure that the cow has a flat and stable supporting weight-bearing surface on hard ground.

The heel of the inner claw is not trimmed down unless overgrown. Furthermore, since claw lesions in the outer claw are the more frequent circumstance, preservation of the heel on the inner claw is desired in the event that it is necessary to provide rest to the outer claw by increasing weight-bearing on the inside claw heel.

A proper dorsal wall length (at least 3 inches) will ensure adequate sole thickness particularly at the toe where sole thickness of at least a 1/4 of inch (5-7 mm) is required. The sole in this area should not “give” under pressure. If it does it may indicate that the sole has been trimmed too thin. Thin soles subject the underlying corium to bruising or a greater potential to wear through, particularly at the white line. Exposure of the corium often leads to grave consequences for the foot.

STEP 2

Using the medial claw just trimmed as a guide, trim the toe of the outer claw (rear foot) to the same length. Next, pare the weight-bearing surface (of the sole) of the outside claw to the same level as that of the medial claw. The outer claw is trimmed to the same level as the inner claw both at the toe and at the heel. Again, the bearing surface should be flat and balanced with the outer claw. Leaving a damaged outer claw higher than the inner claw will probably lead to lameness. It is for this reason that the inner claw heel is preserved. When complete the weight-bearing surfaces should be flat at the toe.

STEP 3

Shape and slope the sole so that the innermost back portion of the sole slopes toward the center of the claws. Care should be taken to avoid paring away important weight-bearing surface at the toe. Excessive cupping or sloping of the sole should be avoided because it reduces the weight-bearing surface area to the outside walls. This is one of the most common errors in foot trimming. Proper sloping of the sole in this region is designed to reduce pressure in the sole-ulcer site area and open the interdigital space between the claws. Overgrowth of the sole which occludes the interdigital space causes dirt and manure to be entrapped between the claws. This increases the likelihood of interdigital disease.

STEP 4

Balance the heels. Weight-bearing surfaces should be flat at the toes, along the walls, and across the heels. This assures an appropriate distribution of weight within and between the claws and completes the trimming process in feet where further corrective trimming procedures are unnecessary.

Steps 5 and 6 are characterized as “therapeutic and curative trimming procedures”. They are applied as needed.

STEP 5

Pare the damaged claw lower toward the heel to increase weight-bearing on the healthy claw. In most cases the damaged claw will be the outside claw of rear and the medial claw of front feet. Specific indications for this trimming procedure would include conditions in which overgrowth has led to overloading (i.e. hemorrhage at the sole ulcer site) or excessive weight-bearing on the claw. Lowering the damaged claw reduces weight-bearing and thereby permits recovery and eventual return to normal function and health. In some cases it is necessary to apply a footblock to the healthy claw in order to reduce weight-bearing in the damaged claw.

STEP 6

In the presence of hoof horn lesions, further corrective trimming is necessary. Remove all loose horn irrespective of how extensive it is (sole separation) and pare away hard ridges (heel horn erosion). Only healthy hoof horn should be left in place.

Never dig holes. Always slope horn towards the lesion. For example, trim the area around sole ulcers and remove the lateral wall when trimming out white line lesions. Trim carefully and DO NOT remove new healthy horn. Avoid damage to the corium (ie. stop when trimming leads to bleeding of the corium).

Do not trim horn with cracks or hemorrhage of the sole excessively; unless there is pain or swelling. Once necessary horn removal has been accomplished, avoid cutting away more horn at each examination unless conditions (ie. loose or damaged horn) warrant such measures.

Part of fixing a foot is trimming a foot. In other words, unless the defect that created the problem is corrected the benefits from curative procedures are short-lived. The step-wise procedure as outlined above, if followed, forces one to observe and trim the healthy as well as the lame foot in a lame cow. Quite often, similar problems can be found in the other foot. Cows that do not respond or get worse within a couple of days should be re-examined.

It is the opinion of these authors that every dairy should have (at the very least) facilities for performing foot care and trimming procedures. Large herds (300 hundred cows or more) should consider training personnel on the farm to fix and trim feet on a regular or daily basis. This will assure timely care of lameness and prevent loss of cows from irreversible foot disease.

Interdigital Dermatitis (Heel Erosion, Slurry Heel, Stinky Foot, Stable Footrot)

Interdigital dermatitis is an acute or chronic inflammation of the interdigital skin, extending to the dermis. It results initially in reddening and superficial erosion that often leads to a liquefaction of epidermal cells accompanied by a characteristic fetid smell. The lesion is often painful to the touch. In many cases the condition extends to the heel horn resulting in heel erosion. In the initial stages the heel horn develops a pitted appearance but later fissures with undermining of heel horn appears. In more chronic cases there is thickening of the interdigital skin which may lead to secondary "corn" formation

Interdigital dermatitis occurs worldwide and is believed to be associated with conditions that create a moist claw environment combined with exposure to manure and slurry. Clinical diagnosis is based on thickening of the interdigital skin which is usually easily seen in the dorsal interdigital cleft after cleaning. A pungent odor, pain to the touch and the concurrent presence of heel erosion are additional clinical features.

As skin lesions usually regress spontaneously when the environment is cleaned up, proper management of manure and slurry removal as well as proper housing facilities are important. Foot bathing is believed to assist in the control of environmental contamination. Interdigital dermatitis is reported to respond to formalin footbathing. It is recommended that a 3-5% solution be used twice daily for 3 days in 3-4 week cycles. Ideally two baths should be used the first consisting of a water-bath to clean the feet. The baths should be placed at the exit from the milking parlor. After having walked through the footbaths, the cows should be kept in a clean area for 30 minutes. This allows drainage of the excess fluid and time for the formalin to exert its antibacterial action. In addition, formalin aids in hardening of the claw horn and skin. Formalin is a skin irritant and should not be used in concentrations exceeding 5% or for longer than three consecutive days.

Foot Rot

Foot rot is a contagious disease of cattle characterized by the development of a necrotic lesion in the interdigital skin. The accompanying cellulitis extends into the soft tissues of the foot causing swelling and lameness. The lesion has a typically foul odor which some find helpful in distinguishing it from other conditions. Incidence appears to be higher during the winter months and in confinement-housed cattle.

Recently a new more severe form of the disease has been observed. It has been termed "Super Foul" or "Super Foot Rot". It is described as a fulminating infection that causes extensive interdigital tissue damage and swelling that extends well up the leg. Unless treatment is approached early and aggressively results are not favorable.

Environmental factors associated with these disorders may include housing conditions which require cows to walk through or stand in manure slurry for extended periods. Since the causative organisms are believed to originate from the gastrointestinal tract of the cow it would be reasonable to expect that manure management would be helpful to reducing the occurrence of the disease. Removing extraneous debris from walkways and alleyways to avoid interdigital skin lesions and keeping cattle habitat as dry as possible are believed to major considerations in the prevention of foot rot problems.

Treatment generally requires systemic antibiotic therapy. Treatments of choice are Naxcel (Ceftiofur Sodium), Penicillin, Albon (Sulfadimethoxine), and tetracyclines (extra-label in dairy cattle). Some prefer to simultaneously treat the interdigital lesion as well. Various antiseptic type products may be used as topical treatments. Bandaging of the foot is optional. Regardless, the secret to success is early detection of the disease.

Papillomatous Digital Dermatitis

Digital dermatitis was first described in 1974 by Drs. Cheli and Mortellaro from Italy. In the United States the condition is known by a variety of different terms including: hairy heel warts, digital warts, strawberry foot, raspberry heel, verrucous dermatitis, Mortellaro or Mortellaro's disease, papillomatous digital dermatitis, and digital dermatitis. Regardless of the terminology applied to this condition, it is recognized worldwide as a frustrating, if not serious, health problem. Most perplexing in recent years has been the dramatic increase in incidence of this disease. Even more troubling, is the fact that the precise cause (or causes) and factors which predispose to its occurrence in herds, are largely unclear.

Recent survey data from California cited the following as risk factors for digital dermatitis: 1) large herds, 2) herds with predominately Holsteins, 3) herds with corral housing in winter (muddy conditions prevail at this time), and 4) herds using footbaths. Others have theorized that wet muddy conditions favored the propagation of this disease in herds, however until this survey there was little to substantiate this view. More obvious has been the observation of a higher incidence of digital dermatitis amongst herds which purchased cattle or had heifers and young stock raised off-farm for return at a later date. There remain a few closed herds that have never developed a case of foot warts. Finally, it's of more than just casual interest that footbaths were recognized as a significant risk factor. These are particularly difficult as well as costly to manage properly in large herds.

Early approaches to therapy in the United States included surgical excision, footbaths and/or topical treatment with various disinfectants and caustic chemicals, cryosurgery (freezing), and electrocautery (burning). More recently, topical antibiotic treatment under a bandage has become a popular method to treat individual animals; specifically, topical treatment with cotton balls or gauze soaked in oxytetracycline hydrochloride or in a lincomycin/spectinomycin combination product under a bandage. Most cows are remarkably improved within 24-48 hours. Bandages can be removed 3 to 5 days following application.

There is surprisingly little controlled data to substantiate the use of footbaths for control of lameness, let alone footwarts. When used as the sole method of treatment or control, effectiveness varies considerably. Most report little or no benefit from the use of copper sulfate for treatment of footwarts. Recent marketing of a pH adjusted copper sulfate product has shown better results but may not be sufficient alone. Formaldehyde at a 3-5% concentration appears effective for some but not for others. The use of formaldehyde is further complicated by concerns for worker safety. Several states have, or are, placing restrictions on the use of formaldehyde in footbaths.

Tetracycline or oxytetracycline at rates of 1-10 grams/liter of water have been advised and are reported to be effective if managed properly. Still others prefer to medicate their footbaths with a lincomycin/spectinomycin (LS-50) combination product or lincomycin alone, at the rate of .1-.5 g/liter of

water. A veterinary practitioner from England reports successful control of footwarts with a single monthly passage through a footbath containing 5-6 g/liter of oxytetracycline (Pfizer) or 150 g LincoSpectin-100 (Upjohn) in 200 liters of water. The major concern with antibiotics in footbaths is residues from direct contamination (through splashing) of the udder and teats or from oral ingestion of footbath solutions by cows.

A series of trials conducted in Florida have found topical spray treatment with either oxytetracycline or lincomycin very effective at managing digital dermatitis. Test of an adjusted copper sulfate formulation (Hoof Pro Plus) as a topical spray was demonstrated to be effective as well although not quite as effective as the antibiotic preparations. Topical spray treatment has several advantages over the footbath approach: 1) less expensive, 2) higher concentration of drug can be applied directly to the lesion, 3) less potential for neutralization from organic material, and 4) less potential for antibiotic residue from ingestion by the cow. See Appendix I for suggestions on spray treatment formulations.

Summary

Feet and leg problems constitute a major health problem for many dairy herds. The causes and/or predisposing factors are many and include: nutrition and feeding, housing and environment, concurrent disease, management factors and genetic influences. The majority of lameness (> 90%) involves the foot. Claw diseases (sole ulcers and white line disease) are a primary cause of lameness in most herds and are predisposed by laminitis and confinement on concrete. Footrot, interdigital dermatitis, and digital dermatitis are diseases with an infectious component responsive to antibiotic treatment, particularly when identified early-on in the course of disease. Manure slurry, mud, and otherwise wet conditions seem to favor the occurrence of these diseases, however specific data to support these thoughts is limited.

Selected References

- Blowey RW: Interdigital causes of lameness. International conference on bovine lameness, June 26-30, 1994, p. 142-153.
- Blowey, RW: Laminitis (Coriosis) - Major risk factors. Proceedings of the North American Veterinary Conference, January 1996, p. 613-614.
- Blood, Henderson and Radostits: Veterinary Medicine. Fifth Edition, 1979.
- Brizzi, A: Bovine digital dermatitis. The Bovine Practitioner, September, 1993, No. 27, p. 33-37.
- Clackson, DA, and Ward, WR: Farm tracks, stockman's herding and lameness in dairy cattle. Vet Record, 1991, 129:511-512.
- Clarkson, MJ, et al: An epidemiological study to determine the risk factors of lameness in dairy cows. (As cited by Ward), Proceedings of the International Conference on Bovine Lameness, Banff, Canada, 1994, p. 301-302.
- Egerton JR, Yong, WK, and Riffkin, GG: Footrot and Foot Abscesses of Ruminants. CRC Press, 1989.
- Esslemont, RJ and Peeler EJ: The scope for raising margins in dairy herds by improving fertility and health. Br. Vet. J. 1993, 149:537-547.
- Greenough, PR: "The subclinical laminitis syndrome". The Bovine Practitioner, 1985, 20:144-149.
- Greenough, PR: "Pododermatitis Circumscripta (Ulceration of the Sole) in Cattle". Agri-Practice, Nov-Dec 1987, p. 17-22.
- Guard, C: Recognizing and managing infectious causes of lameness in cattle. The AABP Proceedings, January 1995, No. 27, p. 80-82.
- Guard, C: Laminitis in dairy cattle: Recognition of the disorder and management of the causative factors. The AABP Proceedings, January 1996, No. 28, p. 71-74.
- Leonard, F, et al: Effect of overcrowded housing conditions on foot lesion development in first-calved Friesian heifers. Proceedings of the International Conference on Bovine Lameness, Banff, Canada, 1994, p. 299-300.
- McDaniel, BT: "Management and housing factors affecting feet and leg soundness in dairy cattle". Proceedings of the American Association of Bovine Practitioners 1983, 14:41-49.
- Mortellaro, CM: Digital dermatitis. International conference on bovine lameness, Banff, Canada, June 26-30, 1994, p. 137-

- Mortensen, K: Bovine laminitis (diffuse aseptic pododermatitis) clinical and pathological findings. Proceedings of the International Conference on Bovine Lameness, Banff, Canada, 1994, p. 210-226.
- Nelson, DR, and Petersen, GC: "Foot Diseases in Cattle. Part I. Examination and special procedures". Compendium of Continuing Education 1984, 6;9:543-550.
- Ossent, P, and Lischer, CJ: Theories on the pathogenesis of bovine laminitis. Proceedings of the International Conference on Bovine Lameness, Banff, Canada, 1994, p. 207-209.
- Petersen, GC, and Nelson, DR: "Foot Diseases in Cattle. Part II. Diagnosis and treatment". Compendium of Continuing Education 1984, 6;10:565-573.
- Raven, T: Cattle Footcare and Claw Trimming. Farming Press Ltd., 1989.
- Rodriguez-Lainz, A, Hird, DW, Walker, RL, and Read, DH: Papillomatous digital dermatitis in 458 dairies. JAVMA, 1996, 209(8):1464-1467.
- Shearer, JK: Footwarts (Digital Dermatitis) treatment and control strategies. Proceedings of the World Dairy Expo 1995, Madison, Wisconsin.
- Shearer, JK: Lameness in dairy cattle: laminitis, claw disease, digital dermatitis, and foot rot. ADSA 91st Annual Meeting, JDS, Vol. 79, Suppl. 1, P235, p.189.
- Stanek, C, et al: Does the claw trimming procedure affect milk yield and milk quality factors? Proceedings of the International Conference on bovine lameness, Banff, Canada, 1994, p. 306-317.
- Vermunt, JJ: Predisposing causes of laminitis. Proceedings of the International Conference Bovine Lameness, Banff, Canada, 1994, p. 236-258.
- Walker, RL: Footwarts in dairy cattle: Current understanding of a complex disease. Proceedings of the 2nd Western Large Herd Dairy Management Conference, April 6-8, 1995, p. 33-40.
- Ward, RW: Recent studies on the epidemiology of lameness. Proceedings of the International Conference on Bovine Lameness, Banff, Canada, 1994, p.197-203.
- Ward, RW: The role of stockmanship in foot lameness in UK dairy cattle. Proceedings of the International Conference on Bovine Lameness, Banff, Canada, 1994, p. 301-302.
- Weaver, DA: "Digital Sepsis: Etiology and Control". The Bovine Practitioner 1988, p. 23.

APPENDIX I.

TOPICAL TREATMENT FOR DIGITAL DERMATITIS

J.K. Shearer DVM, MS.

SUGGESTED PRODUCTS:

- Terramycin-343 by Pfizer (102.4 grams oxytetracycline HCl)
- Terramycin Soluble Powder by Pfizer (10 grams of oxytetracycline HCl)
- Lincomix soluble powder by Upjohn (16 grams of Lincomycin HCl)

Mixing Instructions :

Oxytetracycline HCl soluble powder

Mix 1 packet of Terramycin-343 in 1 gallon of distilled water. This makes a 25 mg/ml concentration. If using the 51.2 gram packet of Terramycin-343, add 2 packets to 1 gallon of distilled water or 1 packet in a half gallon to achieve same concentration.

Smaller herds or herds treating a smaller number of animals may use 1-2 Terramycin (10 gram packets) in a quart of water. This makes a 10-20 mg/ml concentration of oxytetracycline which is more dilute but still effective.

Lincomycin HCl soluble powder

Mix 1 packet of Lincomix in 2 liters (quarts) of distilled water. This makes an 8 mg/ml concentration of Lincomycin HCl.

Directions For Use:

Use as a topical spray at the rate of 10-20 cc per foot. Apply to heels and interdigital space (cleft) or areas with visible lesions using a garden-type hand pump sprayer or other suitable spray treatment device.

Suggested Treatment Regime**Week 1**

Treat all feet of all cows once daily for a period of 5-7 consecutive days.

Week 2 and beyond*

Continue daily topical spray treatment of all cows with visible lesion(s) only.

*Because lesions tend to reoccur topical spray treatment must continue indefinitely! Periodic retreatment (every 3-4 months of all feet of all cows as described for Week 1 treatment is advised.

Precautions :

This treatment represents an extra-label use of these products, dairymen are advised to consult with their veterinarian for proper labeling and further instruction.