Lameness in Dairy Cattle

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Introduction

Lameness is clearly one of the most important health and welfare issues on today's dairy farms. This is in part a consequence of the increase in size of herds, greater intensity in feeding and management and a greater concern for the potential environmental impact of large scale dairy operations which has led to regulations for the containment of waste, and a gradual shift from pasture to confinement-type housing. While there are advantages, confinement housing can result in reduced cow comfort from increased exposure to hard flooring surfaces. Therefore, it should come as no surprise that the incidence of lameness continues to increase. The cow's foot was not designed for prolonged exposure on concrete and in housing conditions that subject claws to constant contact with wet manure slurry. Claw disorders (sole ulcers and white line disease) associated with housing conditions and chronic subclinical laminitis are primary causes of lameness in most herds. Early detection and proper treatment of lameness minimizes losses, improves outcome, and reduces animal suffering.

Normal Gait in Cattle

The cow's stride consists of the stance phase (standing position) and the swing phase (movement from, and back to, the standing position). The swing phase is divided into a retraction (contraction or shortening) and protraction (extension or lengthening) phase. The retraction phase of the stride starts with the cow in standing position. The cow begins her stride by shifting body weight to the sole of the weight-bearing surface of the claws which also provides traction as the cow enters the retraction phase of the stride. As the body moves forward and weight is applied to the soles of each claw, the foot is retracted (or lifted upward) toward the body, thus ending the retraction phase. Once the foot leaves the ground it is extended forward thus entering the protraction phase (forward swing and placement of the foot on the ground surface) of the stride. The heels strike the ground first with the soles resuming a normal weight-bearing position as the cow completes the protraction phase and reaches the standing position. In a sense the rear legs propel the cow's body forward while the front legs act more like props or supports for the body weight.

Gait characteristics are altered by conditions which make the surfaces of floors more or less slippery. For example, on wet manure slurry covered concrete floors cows will alter their gait by lowering walking speeds, changing limb angles and reducing the length of their step, all in an effort to increase stability on the less secure surface. It is interesting to speculate on what effects, if any, this has on claw horn wear rates. In recent years the occurrence of thin soles from

excessive claw horn wear has become a major problem in herds throughout the southeastern United States.

Weight-Bearing in Cattle: Anatomical and Bio-mechanical Factors

Anatomical Considerations. There are important anatomical differences between the lateral and medial claws of rear feet. First of all, the outer claw of the rear foot is larger and it has a much flatter weight bearing surface. This helps to create stability. The inside claw is smaller and it's heel bulb and axial (inside) wall are much less well developed. As a consequence, it's weight bearing surface is sloped toward the axial or inside wall (in other words from the outside wall toward the interdigital space). Thus, when the cow steps forward and places her foot down, weight shifts (or rolls over) from the inside claw to the outside claw. The result is greater weight-bearing on the outside claw that over time (particularly on hard surfaces) leads to irritation of the corium and accelerated hoof horn formation on the outside claw.

Weight Bearing Dynamics During Movement. 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. When viewed 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 Toussaint Raven show these changes in the distribution of weight to be greatest for outside claws. Despite movement, load-bearing on the inside claws is more even (more stable). Outside claws automatically and continuously correct for ever-changing weight load. This circumstance of ever-changing weight distribution is believed to be a major reason for irritation of the corium that results in accelerated hoof growth and a higher incidence of claw disorders involving the outside claw.

Weight Bearing in Front Feet. The situation for front feet is different. Claws of the front foot are similar to each other in size and in terms of the stability of their weight bearing surfaces. Also, there appears to be greater 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.

Confinement on concrete or other hard surfaces enhances the physical effects of load-bearing on feet, whereas housing on earthen surfaces tends to reduce these effects. The practical significance of which is the observation of cattle (especially heifers) that when moved from pasture to confinement may 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. This is sufficient alone to cause to claw disease and is the basis for foot trimming. The correction of claw overgrowth reestablishes proper function and prevents claw disorders.

Suspensory Apparatus and Supporting Structure of the Bovine Digit

Until recently, we knew little about the claw's suspensory apparatus and its significance in the context of foot disease. New information suggests that damage to the suspensory apparatus of P3 is an important predisposing cause of claw lameness.

Cattle (and all animals with hooves) are suspended in their feet, that is, they stand in their feet, not on them. In other words, the bone within the claw (also known as the 3rd phalanx or P_3, for short) is suspended within the claw horn capsule by the laminar corium and a series of collagen fiber bundles that stretch from the insertion zone on the surface of P_3 to the basement membrane of the epidermis (the line of demarcation between dermis and epidermis). The interface between dermal and epidermal components is the interdigitating dermal and epidermal laminae. The result is that P_3 hangs within the claw capsule and weight is transferred as tension onto the wall of the claw capsule.

The suspensory system in cattle differs significantly from that of horses. First, the laminar corium is much less extensive in cattle as compared to horses. Secondly, there are no secondary laminae in the laminar corium of cattle. Therefore, capabilities with respect to mechanical load carried on the claws of cattle, varies significantly. In the horse load bearing is primarily on the wall. Cattle, on the other hand, simply cannot handle the same amount of mechanical load on the walls of their claws. Instead, weight bearing in cattle requires displacement of load to the wall, and support structures within the sole and heel. The primary support structures within the bovine claw are the digital cushions which consist of loose connective and adipose (fat) tissue. They serve as shock absorbers and permit limited movement of P_3 within the claw capsule.

Laminitis and its Relationship to Claw Disease

In the classical description of laminitis, blood flow in the micro-circulatory system of the corium is disrupted leading to breakdown and separation of the dermal-epidermal junction between the hoof wall and underlying tissue. This is accompanied by sinking and rotation of the 3rd phalanx (P_3) which results in permanent damage to the hoof and enclosed structures. Indeed, the study of hoof lesions clearly demonstrates this to be the outcome of severe laminitis in horses. However, in contrast to the horse, the lesions of laminitis in cattle appear to be quite different. Studies by Swiss and German researchers indicate that although laminitis in cattle results in sinking of P_3, it is not due to an actual separation of the dermal-epidermal junction as occurs in horses. Instead, sinking of P_3 results from an elongation or loosening of collagen fibers within the collagen fiber bundles within the corium which make up the claw's suspensory apparatus.

Sinking of P_3 results in compression of the corium between P_3 and the sole which sets the stage for development of sole ulcers. In some cases this "P_3 sinking phenomenon" involves severe rotation of the toe of 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, sinking of P_3 is such that the rear portion of P_3 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).

A second lesion associated with laminitis is the accelerated growth of poorly keratinized claw horn. This is brought about by the release of horn growth and necrosis factors, and the disruption of blood flow which reduces the supply of oxygen and nutrients available for the synthesis of claw horn. The consequence of these events is vascular compromise and the production of poor quality horn. This is observed as claws which become quickly overgrown and grossly abnormal. Claw horn may be softer or have a flaky consistency. In some cases it may be observed to have a yellowish discoloration.

In short, laminitis leads to: 1) damage to the connective tissues of the suspensory and supporting apparatus of the foot, 2) damage of the vascular tissue within the corium, and 3) an interruption in the proper function and development of epidermal cells which ultimately become claw horn. These lesions are responsible for the disorders (sole ulcers and white line disease) described in the following. They constitute the most common causes of lameness in dairy cattle under modern housing conditions.

Sole Ulcers

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 with the knife.

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 (front) and abaxial (outside) 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 exacerbates pinching and dysfunction of the underlying corium and leads to development of the lesion. Treatment requires corrective trimming to remove the necrotic (dead or decaying) horn tissue followed by elevation of the affected claw with a foot-block attached to the unaffected claw. All healthy horn tissue should be left in place.

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

White Line Disease

Areas of hemorrhage with the corium are often most noticeable and severe in the white line region of the sole. This corresponds to one of the primary weight-bearing regions 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, they gradually rise to the surface of the sole (as the solar horn grows) over a period of 6-8 weeks. At this point they become visible and useful as indicators of disease of the corium most commonly associated with subclinical laminitis.

Another outcome with laminar necrosis associated with laminitis is the formation of subsolar abscesses. Some of these abscesses are sterile but nonetheless troublesome as they cause acute lameness in affected animals. However, abscesses 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 a couple of reasons for this: 1) white line separation and distorted claw growth which results in weight-bearing disparities and widening of the white line, and 2) hoof horn formed by the diseased corium is softer and thus more subject to wear and penetration by foreign material from the environment. As a consequence, the incidence of white line disease tends to increase in herds suffering laminitis.

Regardless of how the abscess develops, it is treated by the paring away of all loose and damaged horn and drainage of the abscess. For abscesses which develop as a result of penetration through the white line or sole, establishing drainage is necessary. The site of entry can usually be visualized as a dark area packed with extraneous debris on the surface of the sole (usually in the abaxial white line heel area). 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 and adjacent hoof wall leading to the abscess is required until drainage is accomplished. Removal of the wall adjacent to white line disease abscesses reduces weight-bearing and thus discomfort associated with the lesion. Care should be taken to remove all loose necrotic horn and establish drainage while being careful to minimize peripheral damage. Many animals will show immediate improvement, whereas others in which abscessation was more extensive may take several days to weeks 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 fall off (or wear off) after a period of several days to a couple of weeks.

Heat Stress, Rumen Acidosis, Acid-Base Balance and Lameness

Decreasing the forage to concentrate ratio of diets during periods of hot weather may help to maintain dry matter intake. However, since such strategies often predispose to rumen acidosis they are generally ill advised. Feeding behavior of cows is altered during periods of heat stress.

For example, where concentrates and forages are offered separately, the consumption of forages tends to decline more rapidly and to a greater extent than the intake of concentrate feeds. In addition, intake is less consistent as cows tend to eat fewer meals but more at each feeding session. This is often referred to as "slug feeding" and in itself encourages rumen acidosis. Consistent intake is a primary objective of feeding in hot weather conditions. The combination of energy dense rations and intermittent feeding patterns increases the risk for acidosis problems and consequently, laminitis in hot weather.

Another significant contributor to rumen acidosis during periods of heat stress relates to changes in the cow's acid-base balance. The primary avenues for evaporative heat loss during periods of hot weather are sweating and panting. As temperatures rise, both sweating and respiratory rates increase. In severe heat, panting progresses to open-mouth breathing characterized by a lower respiratory rate and a greater tidal volume. The consequence is respiratory alkalosis as a result of the rapid loss of carbon dioxide. The cow compensates by increasing urinary output of bicarbonate (HCO_3). Simultaneously, the salivary HCO_3 pool for rumen buffering is decreased because of the loss of saliva which occurs from drooling in severely stressed cows. The end result is less rumen buffering and a reduction in total buffering capacity.

Rumen pH is largely determined by the balance between the acids generated from the fermentation of feedstuffs and the bicarbonate and phosphate buffers in saliva which neutralize these acids. Physically effective fiber stimulates chewing and chewing stimulates saliva secretion. Consequently, consistent intake of feedstuffs with effective fiber and cud-chewing are essential for rumen buffering. Saliva flow rates in beef and dairy cattle are estimated to be in the range of 108 to 308 liters (28 to 81 gallons) per day. At these rates of saliva flow it is estimated that the cow can contribute in the range of 390 to 1115 grams (.86 to 2.5 lb) of disodium phosphate and 1134 to 3234 grams (2.5 to 7.1 lb) of sodium bicarbonate for rumen buffering daily. Reduced feed intake, a preference for concentrates rather than forage, a loss of salivary buffering from increased respiratory rates and drooling, and a reduction in the total buffering pool all contribute to a greater potential for rumen acidosis during periods of hot and humid weather, and may explain in part, why some herds experience more acidosis and lameness despite being fed properly formulated rations.

Claw Trimming: 2 Approaches

In the preface of Toussaint Raven's book "Cattle Footcare and Claw Trimming", he gives a very important warning that *"If there is no lameness problem, trimming can produce it"*. Although footcare and claw trimming have an important role in the management of lameness conditions, experience has shown that on occasion claw trimming can be a cause for lameness. The most common error in the US is over-trimming. It is important to remember that one of the primary purposes of the claw horn capsule is to protect the corium. When excess claw horn has been removed and the sole is no longer able to properly support the cow's body weight, the underlying corium becomes subject to damage from bruising. Further, in herds with abrasive flooring surfaces cows may develop thin soles from excessive wear. Thin soles in dairy cattle represent one of the most difficult of foot problems to manage. The functional and corrective trimming method as described by Raven provides important guidelines for the maintenance of

proper toe length and sole thickness. These guidelines are useful to prevent trimming-related lameness.

The Traditional Approach to Claw Trimming. Claw trimming techniques applied to cattle are based largely on procedures used by farriers and others trimming the hooves of horses whereby weight is transferred primarily to the hoof wall. Application of this same technique to the cow would consist of shortening the axial wall and sloping or "cupping out" the sole in order to place the majority of weight on the abaxial wall. This is problematic in that underdevelopment of the axial wall and sloping of the sole toward the axial wall are primary reasons for instability of the medial claw of the rear foot under natural conditions. Removal of the axial wall in both claws only exacerbates instability in the foot. Furthermore, transfer of weight-bearing to the abaxial walls naturally increases shearing forces on the walls. Some suggest that this may increase the risk of white line separation and thus white line disease. Based on the work of Raven, sloping of the soles in an axial direction may also encourage the development of sole ulcers by shifting weight-bearing within the claw onto the "typical site" for sole ulcers. Finally, when the soles of claws are sloped axially, claws are encouraged to splay apart when weight is borne on the foot. This causes stretching and irritation of the interdigital skin and is believed by some to contribute to interdigital fibromas in cattle.

Another complication of traditional trimming techniques is that there is no attempt to balance weight-bearing within or between the claws. Studies on the pathogenesis of sole ulcers and white line disease clearly show that claw overgrowth leads to disproportionate weight-bearing and eventually claw disease. The reestablishment of appropriate weight-bearing within and between claws is therefore an important objective in hoof trimming and represents a major difference between the traditional and functional claw trimming techniques.

Finally, many who apply traditional trimming procedures complete their job by grinding or chipping away wall horn near the weight-bearing surface. Cosmetically, its appearance may be more appealing, but in terms of function the claw and it's weight bearing surface are made weaker and more vulnerable to lesions of the horny capsule. Removal of the wall not only reduces surface area for weight-bearing, but also eliminates the hardest part of the weight-bearing surface. It requires the cow to bear weight on the white line, sole and heel only.

Functional and Corrective Claw Trimming. Functional claw trimming is the method described by Raven. Readers are advised to consult this book for a more in-depth review of this topic.

The objectives of preventative hoof (claw) trimming are:

1. 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).

2. Restoration of the appropriate weight-bearing surface within each claw.

3. Correction of claw lesions at an early stage.

The following describes a 4-step functional trimming procedure based on the Raven method. Although the end result is the same, the 4-step procedure permits greater emphasis on heel balance (Step 4) which these authors consider to be crucial to prevention of claw disorders most of which tend to occur in the heel of the outer claw.

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 claw should be a minimum of 7.5 cm (8 cm or more in a very large cow or bull) in length. The point of measurement is from just below the skin-horn junction where the hard horn starts to the tip of the toe. This length of 7.5 cm should be taken as the minimum front wall length for the average Holstein-Friesian cow. Minimum sole thickness should be from 5 to 7 mm. Trimmers are advised to spare as much heel on the medial claw as possible so that weight may be transferred to this claw in the event of a lesion occurring in the outer claw.

The bearing surface 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.

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 outside claw to the same level as that of the medial claw. When the front walls of each claw are held at the same level the weight bearing surfaces at the toe should be flat and level with each other.

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. Proper sloping of the sole in this region is designed to reduce pressure in the sole-ulcer site 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 by laying the handle of the hoof knife across the heels and making the weight bearing surfaces perpendicular to the long axis of the leg. When trimming is complete the weight-bearing surfaces should be flat at the toes, along the walls, across the heels and perpendicular with the long axis of the leg. 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.

Additional Comments on Functional Trimming: Van Amstel and co-workers compared sole thickness following trimming by one of two methods: 1) paring of the sole until re-connection of the white line of the sole occurred, or 2) according to the Dutch method as described in Steps 1 and 2. Use of the white line re-connection technique resulted in a sole thickness of less than 5 mm in 7/48 (14.6%) claws. Using the Dutch method only 1 of 66 (1.5%) claws was found to have a sole thickness of less than 5 mm. On the other hand, a recent report

by German researchers Paulus and Nuss, indicated that balancing of the weight bearing surfaces (as described in the Dutch method) could result in a thinner sole on the outer claw. These workers proposed that the outer claw may be longer than the medial claw and suggested that strict adherence to the Raven method could cause over-trimming of the outer claw. It is possible that some of the differences noted in these experiments could be explained by differences in the application of specific techniques. However, both studies show how easily over-trimming may occur regardless of the method chosen. The take-home message is - don't bother trimming unless there is significant overgrowth and be especially cautious in herds where cows are housed on concrete.

Corrective Trimming: 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 resulting in postural or gait abnormalities. 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 foot block to the healthy claw in order to reduce weight-bearing in the damaged claw.

Step 6. In the presence of claw 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.

Always slope horn away from 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).

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 should be applied to 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.

Claw Checking and Trimming As Needed

Cows should have their claws checked at least twice per year for the presence of claw horn overgrowth and early lesions. Both abnormalities should be corrected as needed. However, in many situations today, cows are trimmed 2 or 3 times per year whether they need it or not. Trimming normal feet is costly and jeopardizes foot health, especially for cows on concrete where subsequent wear may create thin soles that could lead to serious problems. On the other hand, cows with corkscrew claws or laminitis would likely benefit from trimming as much as 3,

or even 4 times per year because of the accelerated rates of claw horn growth that accompany these conditions.

Foot Blocks for Relief of Weight-Bearing in Diseased Claws

The application of corrective trimming procedures as described in Step 5 will often provide a sufficient difference in height between the two claws to relieve weight-bearing and promote recovery of claw lesions. However, when pain is severe or one is unable to create sufficient difference in height between the two claws, additional elevation of the diseased claw can be achieved by means of a block attached to the sound claw. Proper application of foot blocks requires attention to the following:

1. Start by properly trimming the claws according to the step-wise procedure outlined above. Before attaching a block to the healthy claw, the claw must be pared flat and in the proper plane. This will provide a bearing surface that is at right angles to the long axis of the cannon bone.

2. Prepare the claw with a rasp or grinder so that the adhesive will properly adhere to the wall and sole of the claw being fitted for the block.

3. Mix the adhesive to the proper consistency and apply to the block and claw as needed.

4. Apply the block and position it so that it lies flat on the sole and provides proper support of the heel. Failure to provide adequate heel support is one of the most common mistakes in applying blocks.

5. Be sure that adhesive is cleared away from the area between the block and the heel. Heel horn is very soft and can easily be damaged by the hard and sometimes very sharp edges of fully cured adhesive material.

6. Remove blocks after a period of 4-6 weeks. Blocks that cause discomfort prior to then should be removed sooner.

7. After removing a block, always re-trim the foot and adjust weight-bearing as needed.

Application of Bandages or Wraps to Lesions of the Claw Capsule

Correction of horn lesions often results in small or moderate exposure of the corium. In general, most would agree that minor lesions or injuries to the corium are best left untreated and without a bandage. More severe lesions in which there may be large areas of the corium exposed may benefit from topical treatment with a mild disinfectant or antibiotic under a bandage with the proviso that it be removed within 3-5 days. The direct application of caustic or particularly irritating treatment materials on open lesions with exposed corium should be avoided. If it is the practice of the dairy to allow bandages to fall off on their own it is the opinion of these authors that they are better left without a bandage from the start. The environment of most cows is such that bandages become very contaminated within a couple of days. It is doubtful that they offer

significant therapeutic benefit beyond this point. Indeed, results from a Cornell study comparing cows with claw lesions with a wrap verses no wrap indicate no advantage to the application of bandage.

On the other hand, a bandage is advised for hemostasis in cases where there is severe hemorrhage of the corium or other tissues. Bandages are also advised for postoperative care of surgical cases such as claw amputation. As suggested above, these should be changed every 2 days depending upon the degree of environmental contamination. Every attempt possible should be made to house animals having had such procedures in a clean dry environment.

Infectious Diseases of the Skin of the Foot

Infectious claw disorders represent some of the most important causes of lameness in dairy cattle. However, unlike the lesion associated with a sole ulcer or white line disease which specifically affects the claw, these diseases affect the "skin" of the interdigital space, heel bulbs, and interdigital cleft (on the back of the foot above the interdigital space). Although there are some differences in the way these conditions develop and the way they appear, they all have at least one thing in common: they are believed to be caused by infectious agents capable of inducing inflamation and lameness.

Digital Dermatitis (Mortellaro's Disease) Although digital dermatitis (DD) was first reported in the US around 1980, the disease was not a widespread problem until the early 1990s. Although the precise cause remains to be determined, the organisms observed in lesions most consistently are bacterial spirochetes belonging to the genus *Treponema sp*. Digital dermatitis may cause lameness but this tends to be an inconsistent feature of this disease. Observations in Florida indicate that only about half of the animals affected with DD exhibit lameness. Cows naturally avoid contact with the ground or flooring surface by walking on their toes. In fact, stubbed toes from excessive hoof wear is one indicator of a DD lesion in affected cows. Despite obvious indications of discomfort, research indicates that cows affected with DD are likely to suffer reduced reproductive performance and a tendency for lower milk production.

Lesions associated with this disease are typically round or oval and located on the plantar surface of the foot adjacent to the interdigital cleft. Some lesions are located on or above the heel bulbs and still others may be found adjacent to or near the dew claws. Early lesions are red, raw, and flat. They are extremely sensitive and cows react painfully to spraying with water or other direct contact. Even a mild disturbance of the inflamed tissue tends to result in mild to moderate bleeding. As lesions mature most will enlarge and thicken often resembling a papilloma. This has caused California researchers to refer to the disease as papillomatous digital dermatitis. Hairs at the skin margins remain long and erect serving as distant evidence of what might otherwise be an obscure lesion. On closer inspection one will observe a lesion with characteristics similar to the early lesion with a slightly more raised surface, characterized by some as granular or terrycloth-towel-like. These more mature lesions may be red, tan, or grey. Similar to the early lesion, they are very sensitive and tend to bleed easily if sufficiently disturbed.

Treatment of DD. Approaches to therapy include: 1) surgical excision, 2) footbaths 3) topical treatment with various disinfectants, and antibiotic solutions, 4) cryosurgery, and electrocautery, 5) topical treatment under a bandage, and 6) systemic antibiotic therapy. With the possible exception of cryosurgery and electrocautery, most of these treatments have a place in the management of this condition. Treatment strategies have been reviewed previously.

Topical spray-on treatment with antibiotic and some non-antibiotic preparations (Victory™ by Westfalia-Surge) have been shown to be very effective when used in a scheme of consistent daily treatment for a period of 8-10 days over a 2-week period. The major disadvantage to topical treatment is that lesions occurring in the interdigital space are missed. Topical antibiotic treatment under a bandage is particularly effective with most cows showing remarkable improvement within 24-48 hours. Furthermore, when properly applied this approach to treatment has the potential advantage of reaching lesions affecting the interdigital skin. Footbaths containing various compounds including 3-5% formalin, 5-10% copper sulfate, 20% zinc sulfate, oxytetracycline 1-4 g/l, lincomycin 1-4 g/l, or lincomycin/spectinomycin 1-4 g/l have been recommended. Results vary widely. Footbaths are discussed in greater detail below.

Response to topical antibiotic treatment (y topical spray or bandage) is also influenced by the anatomic location of lesions. Lesions occurring on the plantar interdigital cleft were less likely to respond compared with lesions occurring on the heel bulbs or dewclaws. Limited evidence also suggests that response to therapy may be influenced by lesion maturity and possibly antibiotic resistance patterns of etiologic agents. These factors should be considered in evaluating treatment responses as well as the development of new treatment strategies.

Interdigital dermatitis (Slurry Heel) Interdigital dermatitis (ID) is an acute or chronic inflamation of the interdigital skin, extending to the dermis. It is extremely common in free-stall housing or other situations where the feet of cows are continuously exposed to wet manure slurry or muddy corral conditions. The disease is likely caused by a mixture of bacteria: *Fusobacterium necrophorum*, bacterial spirochetes, and possibly *Dichelobacter nodosus*. In the early stages, ID is characterized by superficial erosion of the interdigital skin that some are able to recognize by its distinctive foul odor. The interdigital lesion is usually painful to the touch and followed by extension of the infection to the heel horn that results in heel erosion, the most readily visible feature of this disease. Early-on the eroded heel horn develops a pitted appearance. As the disease progresses the roughened pitted heel horn may be replaced by fissures which may be sufficient to result in severe undermining of heel and solar horn. Coincident with this heel erosion is an acceleration of hoof horn formation. Excessive hoof formation leads to overgrowth and overloading of the affected claws.

It's these effects of ID that are believed to make it an important predisposing cause of claw disease problems, particularly sole ulcers. Effects of ID on the interdigital skin are similar. Chronic inflamation causes the interdigital skin to thicken eventually resulting in the formation of an interdigital fibroma. The clinical diagnosis of ID is based on the presence of a thickened interdigital skin, pungent characteristic odor, pain to the touch, and the concurrent presence of heel horn erosion.

Treatment of ID Unlike DD, because of their location in the interdigital space, most lesions of ID are not accessible to treatment by topical spray. Furthermore, the specific

treatment of heel horn erosion by topical spray has not been thoroughly studied. Instead, footbaths are the only practical treatment for ID in cows.

Interdigital Phlegmon (Foot Rot) and Super Footrot. Integdigital phlegmon is an infectious disease of the interdigital skin characterized by the presence of an interdigital lesion, swelling, and moderate to severe lameness. Fever ranging from 103-105^{o}F (occasionally higher) is a consistent finding during the acute stages. Although evidence is inconclusive, most believe that interdigital phlegmon develops following injury or abrasion of the interdigital skin. This interdigital injury is secondarily infected by *Fusobacterium necrophorum* alone, or in combination with *Bacteriodes melaninogenicus*, organisms which encourage progression to a more severe and necrotic-type of lesion. Failure to institute treatment early in the course of the disease may lead to complications involving surrounding soft tissues (tendons, tendon sheaths, joint capsules, and bone) ultimately resulting in deep digital sepsis. At this stage, response to medical therapy is quite often unrewarding, thus limiting one's options to either surgery, or possibly euthanasia, in particularly severe cases. A recent study conducted at the University of Florida found that interdigital phlegmon was associated with a 10% decrease in milk production in affected cows. This was greater than the milk loss observed for cows with claw disorders or digital dermatitis. Most cows developed the disease in early lactation as they were approaching peak milk yields which suggests that the occurrence of this disease in early lactation may inhibit a cow's ability to achieve peak milk yields.

In recent years, clinicians from the United Kingdom and the United States have observed a more extreme form of this disease referred to as "Super Footrot". It is characterized by acute onset of lameness and swelling of the foot that progresses rapidly to an ascending cellulitis. The interdigital lesion associated with "Super Footrot" is especially severe and successful treatment particularly challenging.

Treatment of Interdigital Phlegmon (Footrot) and Super Footrot. Interdigital phlegmon is responsive to most antibiotics in common use for cattle. In fact, dose and duration of treatment are likely more important than antibiotic selection. The key to achievement of a successful therapeutic outcome is dependent upon prompt recognition and early implementation of treatment procedures. Systemic therapy plus topical treatment of the interdigital lesion have long been the preferred methods of treatment. In uncomplicated cases, improvement is noticeable within 24-48 hours with good recovery attainable in 3-4 days from the onset of treatment. 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 unnecessary. Regardless, the secret to success is early detection of the disease.

Strains of bacteria responsible for Super Footrot may be particularly resistant to most antibiotics. Culture and susceptibility testing may be useful but the rapid progression of the disease may preclude this as a viable option in existing cases.

Footbaths and Environmental Considerations

Most operations design facilities for placement of footbaths in parlor exit lanes, however, in some operations cows tend to loiter in lanes exiting the parlor. In general, it is best to locate footbaths in pathways or areas where cows tend to keep moving. After traversing through the baths, cows should be kept in a clean dry area for approximately 30 minutes. This allows time for drainage of the excess fluid and for the medications to exert their antibacterial action. Contaminated footbath solutions are discharged into manure holding systems. Here they are diluted with other waste material from the dairy operation and eventually applied to crop fields. Until recently, most have considered the contribution of footbaths to chemical load in the environment to be insignificant and just a part of sound foot care management. However, a recent article in the July 2001 issue of Hoard's Dairymen demonstrated that the use of copper sulfate at the rate of 100 lbs per day equates to 18 tons per year. Considering the typical number of crop acres for an 800 cow dairy, that amounts to an application rate of 5 lbs per acre.

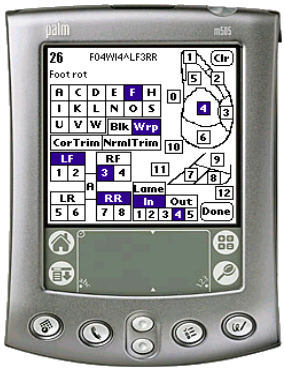
The article cites 2 important problems: 1) phytotoxicity, and 2) Environmental Protection Agency (EPA) guidelines on cumulative loading capacity of soils for heavy metals, including copper. Although copper is a potentially toxic for dairy cattle, the more significant problem relates to phytotoxicity. In high concentrations, copper damages the plant's root system. In some locations crop yields have been greatly reduced as a result of copper toxicity. At current rates of application many dairy operations will achieve the lifetime accumulative load within a period of 10-15 years. Clearly, all operations need to assess the amount of copper sulfate being applied per acre to determine if they are in danger of reaching lifetime accumulative loads. This assessment may be made by multiplying the pounds of copper sulfate purchased annually by .25 to determine the actual amount of copper; then divide this amount by the number of acres that are receiving manure applications.

Records for Monitoring and Managing Lameness in Dairy Herds

Farm records consist of various data and observations that when sorted, categorized, averaged, graphed or otherwise summarized yield information about a particular condition or enterprise that can be used to solve problems, answer questions or identify change. For example, if reduced pregnancy rate is the problem, the underlying causes may be determined by evaluating heat detection or conception rate. The approach to evaluation of lameness in herds is similar. Owners or managers may be aware of an increase in overall herd lameness, but until they know something about the occurrence of specific disorders (e.g. sole ulcers, white line disease, or digital dermatitis) and rates of these conditions, it may be hard to identify potential underlying causes let alone develop a rational management strategy to address them.

For the past 2-3 years the American Association of Bovine Practitioners (AABP) Bovine Lameness Committee's Subcommittee on Records has been trying to develop an improved system for recording observations on bovine lameness. Compatibility with current farm record-keeping systems was considered to be a high priority. Further, it was decided that the system should properly identify or describe lesions consistent with published literature. A prototype of this system is now being tested.

Description of the Proposed System Information for each cow (or foot) may be recorded on the following16 conditions: upper leg (N for non-foot), laminitis (L), ulcers (U), sand or vertical wall cracks (V), white line disease (A for abscess), white line separation (S), sole hemorrhage (H), heel erosion (E), interdigital dermatitis (I), interdigital fibroma (K for korn), digital dermatitis (D), foot rot (F), corkscrew claw (C), thin soles (T), and other (O). Use of the upper case letter and claw zone designation identifies the condition and location of the lesion. For example, U4 (ulcer in zone 4, typical area for sole ulcers) could be used to designate a sole ulcer (U5 a toe ulcer, and U6 a heel ulcer). White line disease abscesses (A) or separations (S) could be identified similarly as A3, A2 and A1, or S3, S2, and S1. Nearly every significant condition of the foot could be identified by use of the appropriate letter and claw zone designation.



Advances in hand held computer technology and windows-type operating systems is rapidly changing the dairymen's ability to input and/or access information. The Dairy Records Management Service group in Raleigh, North Carolina, is developing a version of this system for use with the "PocketDairy" (hand-held computer) program. In its current format data may be recorded chute-side by the trimmer using the computer's touch screen technology. When finished, this system should be able to offer quicker data entry with less opportunity for error.

Training Employees in Foot Care and Claw Trimming Procedures

All dairies (regardless of size) should have appropriate handling and restraint facilities for the treatment of lame cows. Herds of 250 or more cows should have not only handling and restraint facilities (i.e. tilt table or stand-up trimming type chute), but in addition proper equipment (knives, sharpening devices, hoof nippers, and angle grinders) and trained personnel to examine and treat lame cows on a daily basis. Routine maintenance trimming may be left to the services of a commercial trimmer or conducted by on-farm employees at the discretion of the dairy.

The development of effective skills in foot care and claw trimming require supervised training and practice. Training programs such as that described below are advised. Estimated initial investment for dairies who choose to employ an on-farm trimmer (including chute, foot care equipment and training) may range from $5000 to $20,000 (in US dollars). Considering present-day replacement cow costs in the US (greater than $2000/replacement), a foot care program that will reduce the loss of cows to irreversible lameness is easily justified.

The Master Hoof Care Technician Program Training programs in foot care and claw trimming are available from various sources including those who market restraint systems. Some of those teach traditional methods of claw trimming. The Florida Master Hoof Care Technician Program teaches the method of Toussaint Raven. Part I of the course consists of 4 days (3 days of trimming on cadaver specimens and live cows) of intensive training on foot care and claw trimming. Part II consists of continued study and practice of the techniques learned in Part I of the course. After a period of 3 to 6 months of study and practice, the student is eligible to return to the University of Florida to take a written, oral, and laboratory practical examination.

Successful completion of these examinations qualifies the candidate as a “Master Trimmer” in the Master Hoof Care Technician Program. This qualification is the employer’s assurance that his employee is performing the task of foot care and claw trimming in accordance with accepted procedures.

The purpose of the Master Hoof Care Program is to provide training for health technicians responsible for foot care and claw trimming duties on dairy farms. The basis for the program comes from a strong belief that timely (i.e. daily) foot care and treatment of lame cows will reduce the number of cows lost from irreparable foot disease. Unfortunately, many dairies simply turn lame cows out into a lot where they remain until a commercial hoof trimmer or veterinarian can attend to them on their weekly or monthly visit. In these situations, cows go untreated for several days or weeks depending upon when the hoof trimmer or veterinarian is scheduled to visit the dairy. The time lag from original insult to examination and treatment permits treatable lameness conditions to progress to the point of irreparable damage that often results in premature culling of affected animals. This is costly and inhumane. Reducing losses in performance and involuntary culling from lameness has the potential to save the dairy industry millions of dollars to say nothing of the tremendous impact from improvements in animal welfare from providing prompt relief to suffering animals.

In Summary,

Disproportionate weight-bearing on claws leads to hoof overgrowth. This is particularly significant for the outside claw of rear feet and the inside claw of front feet. The inside claw of the rear foot is particularly unstable by virtue of its underdeveloped axial wall. This results in a sloping of the sole toward the interdigital space and a tendency for weight to be shifted to the outside claw. The natural shifting of weight through the pelvis also results in a greater distribution of weight to the outside claw. Despite movement weight-bearing on inside claws of the rear feet is more stable. On concrete effects of these weight-bearing dynamics have significant implications for foot health in cattle. Laminitis increases the risk of claw disorders because of its effect on the displacement of P_3 and the integrity of white line hoof horn. Separation and widening of the white line along with the formation of poorly keratinized horn are important predisposing causes of white line disease associated with laminitis. Appropriate claw health management requires proper foot care and claw trimming techniques. From an international perspective, the functional and corrective claw trimming procedures described by Toussaint Raven are the most widely recognized and accepted claw care and trimming procedures. In the US, however, there are other approaches most of which are based on trimming techniques applied to horses. Generally speaking, the most common trimming error is over-trimming. The Master Hoof Care Program is one example of a training program designed to train dairy employees and others in the proper application of claw care and trimming in the US. Infectious claw disorders (digital dermatitis, interdigital dermatitis, and interdigital phlegmon) are very important disease problems. Treatments may include topical sprays of antibiotics or certain disinfectants, topical treatment under a bandage, footbaths and systemic therapy. Finally, most if not all herds should be monitoring foot disorders, but few herds do. This creates major difficulties for veterinarians and other consultants when trying to solve herd lameness problems. A recently developed system now makes record keeping much easier and more uniform for better use in problem solving lameness problems on dairy farms.

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