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Prevention and control of foot problems in dairy cows

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INTRODUCTION

Foot health and lameness are major issues facing dairy producers because of their common occurrence and the tremendous economic losses incurred. Early detection and prompt treatment can minimize the loss, improve recovery, and reduce animal suffering.

Economic loss is mostly due to the foot problems per se, not the treatment costs. Losses are often subtle, however, depending on the severity, the following components can be identified: body weight loss and decreased milk production, dry matter intake, herd longevity, and reproductive efficiency. The economic implications associated with foot problems can be a minimum of $90 to $100 per case. Depending on the problem and the severity this cost can be higher.

TYPES OF FOOT PROBLEMS

Hard and soft feet

Foot infections, abscesses or sole ulcers may stem from cracks that result when feet are too soft or hard. Excessively soft feet are more apt to occur in free stall systems from standing in manure and urine. This may result in heel and sole cracks allowing ulcers, abscesses or infections to occur.

Excessively hard feet usually occur in stall-barns, especially when kiln-dried shavings or sawdust are used for bedding. This may result in cracks at the top of the foot, which may extend down from the hairline and allow infections relatively high in the foot.

Foot rot

A smelly infection of the foot, which generally occurs high between the claws or toes, is referred to as foot rot. This results mainly from an infection caused by the bacterium, *Fusiformis necrophorus*. The organism may build-up in barnyards, exercise lots, mud-holes, and pastures.

Cattle with foot rot show lameness, usually on one leg only. The foot swells above the coronet and the toes spread. Cracks and fissures develop in the interdigital space. There is a characteristic, foul-smelling exudate at these fissures. If left untreated, the infection can progress into the joint space or tendon sheath producing permanent damage.

Heel erosions

Heel erosions or underrun heels begin at the bulb of the heel. They start out as pits on the surface that can develop into parallel grooves that get filled in with black material and bacteria. The horn can separate at the grooves to form a “flap”. A new sole develops underneath and material becomes packed in between the layers.

TYPES OF FOOT PROBLEMS, CONT.

This condition is usually seen in confined cattle in wet, dirty lots. Overgrown hooves shift the weight toward the heels, exposing the heels to erosion, mostly in the hind claws.

Laminitis

Founder or laminitis can result in long, overgrown and deformed feet or toes. Animals may appear quite lame or stiff and have difficulty in getting up and down.

Hemorrhages can be found in the soles and walls of the feet. Infections, abscesses, or ulcers may occur when foreign material enters places where the wall and sole have separated. The highest incidence of laminitis often occurs during the first 100 days postpartum.

Sole ulcers

Sole ulcers are raw sores usually occurring on the inner side of the outside claw. It is a bulge of granular-like tissue sticking through the sole. Sole ulcers are usually associated with clinical manifestations of laminitis. A general rule of thumb is that if 10 percent of a herd has documented sole ulcers, the herd should be suspected for laminitis. However, there are other factors that can predispose cows to sole ulcers such as moisture and manure, excessive wear, and poor hoof trimming. Sole ulcers usually occur in both hind legs.

Digital dermatitis

In the past 10 years, digital dermatitis has developed as a serious problem in several dairy regions in North America. There are several scientific and common names to characterize the disease. They are heel warts, hairy foot warts, strawberry foot disease, raspberry heel, digital papillomatosis, and Mortellaro disease.

Affected animals have pronounced lameness and spend excessive time lying down. First-calf heifers are often affected, and to a greater degree in the hind feet. There is little to no digital swelling with this disease. Table 1 illustrates the types and percentages of foot lesions seen in herds.

THE BOVINE HOOF

The bovine hoof consists of a hard outer casing or hoof horn, the corium, which contains the blood vessels and horn forming cells, and the skeletal portion of the foot (Figure 1). The coffin bone is the large, terminal, weight-bearing bone around which the hoof is formed and to which the tendons are attached.

The hoof wall, sole, and heel are made of keratin (like hair and the cow's horn) and water. They are not very thick and cover tissues, which hold nerves and blood vessels.

THE BOVINE HOOF, CONT.

The junction between the horn forming tissues of the hoof wall and sole, called the white line, is located around the circumference of the bottom of the hoof. This area is susceptible to physical damage and bacterial invasion.

The hoof grows from the corium at a rate of about 2 inches per year. The rate of growth depends on the genetics of the cow as well as the environment and nutrition of the cow. The rate of hoof growth is greater in the rear feet compared to the front feet.

Weight distribution over the cow's feet is an important factor, which will influence how her feet grow. The major weight bearing area of the foot is the outside part of the outside claw. This area absorbs the highest pressures during midstance. The cows weight then moves towards the toes as she pushes forward. At this point there will be stretching of the white line.

A hoof responds to heavier weight bearing by depositing greater amounts of keratin. In young animals, the weight is pretty evenly placed around the hooves. As the cow matures, more weight is put on the outside walls of the rear feet. This is where they have more overgrowth.

The inner walls of the front feet bear more weight as the cow matures. The bulbs of the heels are not normally weight bearing surfaces. With exaggerated overgrowth of the hoof horn, the body weight shifts and the bulbs of the heel come into contact with the ground. The bulbs are like skin and are loaded with nerves and blood vessels, which make them more sensitive. Some cows with excessively long toes develop lameness because of bruising of the bulbs of the heel.

LAMINITIS

Laminitis is an aseptic inflammation of the dermal layers inside the foot. There is usually some inflammation and sensitivity above the hoof and around the coronary band.

General symptoms of an animal contracting laminitis consist of moving very stiffly and "crampy". Standing on toes on the edge of stalls is very typical of a stance to alleviate pain.

Solar characteristics include sole hemorrhages and yellowish discoloration. Often, a white line separation (juncture between the sole and the outer keratinized wall) may be apparent. Double soles and heel cracks may be present. However, an animal may exhibit pain with no visible or apparent reason for lameness within a given foot.

There is no one specific cause and laminitis may be associated with several, largely interdependent factors. Nutritional management is normally considered a key component in the development of laminitis, especially the feeding of increased fermentable carbohydrates, which leads to rumen acidosis.

Metabolic and digestive disorders can be predisposing factors. Hormonal changes associated with parturition and the lactation cycle can impact certain physiological changes. Infectious diseases, such as mastitis, metritis, and foot rot can impose specific endotoxic insults.

Environmental aspects, such as hard surfaces, lack of or little use of bedding, and lack of or excessive exercise on undesirable surfaces can predispose animals to mechanical damage.

Rumen acidosis

Rumen acidosis has been shown to be a key factor leading to laminitis. Acidosis is caused by the ingestion of greater than normal quantities of ruminally fermentable carbohydrates. This can reduce fiber digestion, increase lactic acid production, reduce feed intake, depress fat test, and increase the occurrence of metabolic diseases.

As fermentable carbohydrates or their rate increases in the diet, the growth rate of all rumen bacteria increases, with increased volatile fatty acid production. As pH decreases, the rumen microbes that produce lactic acid increase. The pH is reduced to even lower levels. This results in a decreased growth rate of many bacterial populations that inhabit the rumen.

As the rumen pH decreases below 5, the lactic acid production is elevated. The increased acidity causes a stasis of fermentation. Endotoxins can be produced and released which can trigger histamine release. This causes vaso-constriction, dilation, laminar destruction, hoof deterioration and the laminitis process develops.

Histamine is a chemical naturally released as a function of stress. Environmental stress and infectious diseases can also cause histamine release.

Acute laminitis

A cow is systematically ill during acute laminitis. Inflammation of the corium is evident. The cow is prone to recurrences if the metabolic insults persist. The major local clinical signs in addition to intense pain include some swelling and temperatures that are slightly warmer than normal above the coronary band in the soft tissue area.

Subclinical laminitis

This can be a long and slow process that is dependent upon persistency of low-grade insults. The inflammation that takes place ultimately results in internal hemorrhaging. As the horn tissue grows, the hemorrhagic area moves to the surface. The interval between the occurrence and appearance of the hemorrhage is related to the growth rate, which is about 0.20 inches per month. The thickness of the normal sole is about 0.40 inches. Therefore, the hemorrhage is seen about two months after the internal insult occurred.

The occurrence of sole hemorrhages and yellow discolorations are signs that subclinical laminitis may be a herd problem. Sole hemorrhages can affect up to 50 to 60 percent of first calf heifers.

LAMINITIS, CONT.

Chronic laminitis

Several changes are associated with the localized area of the digit. The growth pattern of the keratinized horn is disrupted and the shape of the digit is altered. It becomes more elongated, flattened, and broadened. The surface of the claw is deeply grooved giving a rippled appearance. A dish-like appearance to the front of the hoof wall and sole are also characteristic. Internally, the coffin bone has separated from the front of the wall. Double soles with yellowish discoloration continue to be a major clinical sign.

In severe situations, the bottom portion of the coffin bone can protrude through the corium and hard-horned tissue of the sole. Once the disease process has reached this point, the damage has been done and no therapy can return the foot to a normal configuration. The degree of chronic laminitis depends on the intensity and frequency of each acute episode and the degree of damage each preceding episode has caused as a result of the initial insult.

DIGITAL DERMATITIS

Foot wart lesions look like raised, red and yellow patches and are usually located at the back of the foot above the heel. They are particularly painful and prone to bleeding when manipulated. Mature lesions are larger- up to two inches across, and usually raised with long, brown or grayish-black tufts of hair like projections along the surface. They have a hairy wart appearance. The hairs along the lesions are usually "true hairs". The lesions can persist for many months. They may regress with dry weather.

This disease is probably caused by a spirochete bacterium and it appears to be very contagious. The high morbidity of herds contracting this disease, as well as observations that greater than 90 percent of the lesions are highly responsive to antibiotics suggest an infectious agent.

Environment may predispose animals to the foot wart agent. Examples would be wet free stalls, poorly drained lots etc. Spirochetes have been found in digits of healthy cows, in affected herds, and in herds without incidence of digital dermatitis. It appears possible that many animals can be infected with the organism but show no evidence of lameness or lesions. When a specific stress or environmental component triggers the disease, it can then spread very rapidly.

HOOF-CARE TREATMENTS

Treatments can consist of hoof trimming, foot baths, and/or topical applications. Depending on the problem, a veterinarian and hoof trimmer should be consulted as to the best method of treatment. A combination of several treatment protocols may be necessary to correct individual and herd problems.

Restoring feet to proper hardness

If feet are too soft, avoid having cows stand in moist sod for extended periods of time. Allow cows to stand in dry soil or sand, even if it means piling it on concrete for cows to stand on. Routinely use a dry mineral mixture in a walk-through foot box. A formula of 80 percent hydrated lime, 15 percent copper sulfate, and 5 percent flowers of sulfur (acts as an antiseptic) can be used. Barn lime or superphosphate can be used on walkways.

If feet are too hard, avoid having animals stand in soil or muddy areas for extended periods of time. Allow cows to stand or graze on sod, especially when it is moist or dew-ladened, but not soft or muddy. Barn lime or superphosphate should not be used on walkways.

For herd problems, moist clay can be used in a foot box or vat, but slats may be necessary in the container to prevent slipping. Plain water can be used if it is drained and replaced frequently. For individual problems, a hoof ointment can be rubbed into the coronary ban at the hairline of the foot.

Foot rot

Treatment consists of parenteral administration of antibiotics and/or sulfonamides plus local therapy. The interdigital area should be washed and any loose necrotic tissue removed. Topical dressings of antibiotics, sulfas, or antiseptics have been used with success.

If the infection has spread to deeper tissues, a drawing ointment may be beneficial. Affected animals should be separated from the herd and confined to prevent the spread of the organism.

Control of foot rot is important to minimize the economic impact of this contagious disease to the herd. Isolating individual cows, rigid sanitation in high-density areas, and use of a foot bath have proven helpful in controlling the spread of foot rot.

The foot bath should contain five-percent copper sulfate. The depth of the solution should be at least four inches. The foot bath should be located where cattle must pass through it several times a day. An alternative to the foot bath is a dry bath containing one part copper sulfate to nine parts hydrated lime.

Heel erosions

Treatment should be first directed toward removal of all the unsound horn. After cleaning, the exposed area may be treated with a disinfectant liquid. The cow should be confined for several days until the newly exposed sole hardens.

In more severe cases in which sensitive tissue is exposed, a protective bandage applied over an astringent medication may be necessary in addition to confinement. Herd control involves genetic selection for strong feet and legs without excessive slope to the pastern.

HOOF-CARE TREATMENTS, CONT.

Feet should be trimmed regularly and excessive exposure to wet environments should be avoided. A dry foot bath (see treatment for soft feet) may help toughen hoof sole as well as reducing the spread of infection.

Sole ulcers

The initial treatment of sole ulcers is to relieve the pressure on the ulcer. Therapeutic trimming consists of paring out the affected area around the ulcerated sole or lesion, which helps to relieve pressure and allows healing to occur. Topical application of sulfonamides and/or astringents followed by bandaging is necessary to control infection and prevent regrowth of the granulation tissue

Often times the ulcerated area has expanded to the point where no wall structure on the affected digit can be maintained. Therefore, it is often necessary to block or elevate the unaffected toe such that the pressure can be reduced on the affected toe.

Digital dermatitis

There are several treatment protocols that can be used. Since the specific cause of foot warts is unknown, a specific treatment that always works is questionable. There are no treatments labeled for this condition, thus the use of drugs requires a label and instructions from a veterinarian.

In the initial stage of the disease, because of the pain, allowing animals to walk normally is critical. This means desensitization of the infected area by removing debris from the specific lesion plus using a topical application of caustic chemicals and/or antibiotics.

Topical oxytetracycline (soluble powder) and/or the injectable solution can be applied directly to the lesion. LS (Lincomycin/Spectinomycin)-50 powder or a solution has been used successfully. Treatments also have been sprayed on lesion areas. Topical sprays of iodine or iodized copper have proven to be effective for treatment and control. Caustic chemicals should be used with extreme caution. If they are overused on the lesion, they can cause serious lameness because of chemical burns on the skin.

A concentrated foot bath along with topical applications can be effective in controlling foot warts. A foot bath containing a nine to ten-percent solution of copper sulfate can help control foot warts and other infections. Initially it should be used for nine consecutive milkings per week. After a month or two, with good control, use it one milking per day for three days every other week and use it for nine consecutive milkings the other two weeks. If feet get too hard, use foot baths less frequently or use a five-percent copper sulfate solution. A general rule of thumb is to change the foot bath for every 150 to 300 cows.

For large (greater than two inches in diameter), persistent, mature foot warts, surgical removal may be elected. The normal skin peripheral to the base of the wart-like structure must be excised around the entire circumference for the surgical procedure to be successful, otherwise regrowth is common.

PREVENTIVE MANAGEMENT

Preventative management in a herd requires knowing the prevalence of lameness and the animal group(s) affected. This can be determined using a lameness scoring system. Figure 2 illustrates a 5-point scale that can be used to score cows in a herd.

There are several areas on the farm that can lead to bovine lameness. They include nutrition, feeding management, animal behavior, stress, cow comfort, and infrequent hoof trimming.

Lameness is usually a multifactorial problem. Even though nutrition receives attention as being the main cause, other areas should be evaluated.

Nutrition

There are several areas in nutrition that can help reduce the risk of foot problems. They include carbohydrates, protein, trace minerals, and vitamins. Formulating the ideal ration to maintain good hoof health is not always enough. Nutrition should be weighed along with other factors in preventing bovine lameness from being a herd problem.

Carbohydrates

A major challenge regarding nutrition is a lack of information to specify threshold levels of carbohydrate that initiate nutritional insults such as acidosis. Carbohydrates constitute about 70 to 80 percent of the dairy ration. The level and availability in various rations can have a substantial impact on ruminal metabolism. The amount of carbohydrates necessary to induce ruminal acidosis depends on the type of feed processing, the adaptation period, the nutritional status of the cow, and the frequency with which the carbohydrate is fed.

Lactating cows need a minimum amount of forage in the ration. Forages should be included in the diet at no less than 1.40 percent of body weight. In most situations, forage should make up no less than 40 to 45 percent of the total ration dry matter.

The forage and total neutral detergent fiber (NDF) intake of the ration should be evaluated. Cows consume pounds, not percents. Levels of NDF that may be acceptable for cows consuming 50 pounds of dry matter may not be for animals consuming less than 42 pounds (see example box). The minimum forage NDF intake as a percent of body weight should be 0.85. The minimum total NDF intake as a percent of bodyweight should be 1.1 to 1.2.

Example: The average cow bodyweight is 1300 pounds and the total NDF in the ration is 32% on a dry matter basis.

A cow consuming 50 pounds of dry matter would be getting 16 pounds of total NDF (50 x .32) or 1.23% of bodyweight as total NDF.

A cow consuming 42 pounds of dry matter would be getting 13.4 pounds of total NDF (42 x .32) or 1.03% of body weight as total NDF.

The nonfiber carbohydrate fraction is highly digestible and can be quickly digested compared to NDF. Excessive nonfiber carbohydrate (NFC) can depress fiber digestibility, reduce acetic acid production, and lead to rumen acidosis.

PREVENTIVE MANAGEMENT, CONT.

Consideration should be given to the grain's particle size, moisture, and processing method in addition to the level of NFC in the ration. Depending on the digestibility of the NDF present, a NFC between 30 to 40 percent of the total ration dry matter is recommended. In most instances, a NFC between 32 to 38 percent is considered ideal.

The concentration of NFC in a feed can be calculated by subtracting ash, ether extract, crude protein (CP) and crude protein-free NDF from 100.
100- [(NDF-NDFCP)+CP+fat+ash]
Using crude protein-free NDF is especially important for heat damaged forages and heated byproducts because the NDF can contain substantial CP. If CP-free NDF is not used, the CP in the NDF is subtracted twice (once as CP and once as NDF bound CP). When NFC for feed ingredients is calculated using the following equation of *100- [NDF+CP+fat+ash]*, then the NFC of an ingredient may be considerably underestimated (see example box). This can underestimate the NFC value in the total ration dry matter by 2 to 4 percent.

Example calculation:
Alfalfa silage on a dry matter basis contains: CP-19.6%, NDF-48.8%, NDFCP-4.1%, Fat-2.9%, and Ash-9.3%

100- [(NDF-NDFCP)+CP+fat+ash]
100-[(48.8-4.1)+19.6+2.9+9.3] =
23.5% NFC

100- [NDF+CP+fat+ash]
100- [48.8+19.6+2.9+9.3] =
19.4% NFC

Protein

The amount of protein in the ration has been suggested to influence the incidence of laminitis. Several studies have shown that high percentages of ruminally degraded protein have been identified in association with lameness and laminitis. However, the role of protein is still unclear.

Little information is available to identify what role protein might play in the development of lameness. Several postulations involve allergic histaminic reactions to certain types of proteins or a link between high protein supplementation and protein degradation end products. Table 2 list guidelines for protein levels in dairy cattle diets.

Trace minerals

Copper is essential for the production of a healthy claw horn. A copper deficiency can interfere with the synthesis of keratin, inhibiting development of the horn tissue.

Zinc is essential for horn production and plays an important role in immunity. The effect of zinc on bovine lameness is normally related to wound healing, epithelial tissue repair, hoof hardness, and maintenance of cellular integrity.

Many nutritionists formulate rations with higher levels of trace minerals than what NRC recommends to take into account stress related problems due to increased milk production and/or disease. Table 2 list suggested guidelines for trace minerals and vitamins.

Vitamins

Vitamin A, beta-carotene, vitamin E, and biotin are of concern when studying factors related to cattle lameness. Vitamin A is important in the maintenance of epithelial tissue and cell replication. Beta-carotene is thought to play a role in both epithelial tissue repair and integrity and immune function.

Vitamin E is involved in helping cells maintain integrity and in the immune process. Its major role is that of an antioxidant.

Biotin is associated with the formation of the hoof horn. It is important in claw hardness. If rations are high in concentrates, the synthesis of biotin in the rumen is reduced. The current recommendation is to supplement 20 mg per day of biotin through lactation and 10 mg per day for dry cows. The cost is typically six to eight cents per cow per day. Response to biotin may take several months.

Feeding management

The incidence of lameness and laminitis can be controlled through good nutrition and use of proper feeding management practices. The areas that impact the feet the most are feeding frequency, particle size of both forages and grains, transitioning animals onto different diets, and first calf heifers moving into the milking herd.

Dairy herds fed conventionally should feed grain at least twice daily. For cows milking over 80 pounds, feeding grain three to four times per day would be ideal. Hay or some forage should be fed before grain is offered.

Herds feeding a total mixed ration (TMR) should monitor dry matters on all high moisture feeds on a regular basis. The herd TMR should be analyzed at least quarterly to check that levels of nutrients are close to what has been programmed. A true TMR should be fed. Any forage or grain offered outside of the TMR allows cows to preferentially choose what they want to consume.

Dietary buffers should be included in the diet. A buffer can be included in the ration at 0.80 percent of the total ration dry matter. However, do not rely solely on offering a buffer free choice to cows to correct a rumen acidosis problem.

Particle size is an important factor for both the forages and grains being fed. Forages and/or total mixed rations that are too fine in particle size, coupled with inadequate forage or fiber levels can aggravate lameness problems. Cows need effective fiber in the diet to maintain normal rumen function. The main objective in analyzing the particle size of the TMR is to measure the distribution of feed and forage particles that the cows actually consume. Table 3 lists particle size guidelines for forages and TMRs.

Particle size, processing method and moisture content can affect the ruminal availability of structural and nonfiber carbohydrates. These factors need to be considered, in addition to levels used, when formulating rations.

Gradual transitions should be made when switching animals from one type of diet to another. At least two weeks prior to calving, animals should be lead fed concentrates up to 0.5 to 0.75 percent of body weight.

Ideally, first calf heifers should have their own separate group and ration developed that takes into account their smaller body weights and their specific requirements.

Behavior and stress

Dairy cows should be allowed to lie 10 to 14 hours per day. Their lying time can be reduced because of poorly designed housing or stalls that are uncomfortable or too few in number. Prolonged standing causes sore feet that can become susceptible to disease.

Exercise is important for stimulating blood flow through the feet and keeping the tissues healthy. Too little exercise can cause sluggish blood flow, edema, and swelling. Too much exercise and concussion on concrete floors, especially for heifers that have been on pasture, can cause trauma and mechanical damage and a greater incidence of sole ulceration.

First calf heifers may need to be managed differently from older animals to minimize laminitis in this group. Predisposing factors are a sudden introduction of heifers into a mature cow group, development of a pecking order, and overcrowding heifers.

If heifers are overcrowded, they usually will find their way to the bunk when space is available. They will engorge themselves three to four times a day instead of the normal 13 to 14 meals, thus predisposing them to rumen acidosis.

Mechanical development of hemorrhaging and/or ulceration can also occur in heifers simply as a result of trauma incurred from being transposed from earthen lots to concrete floors. Preventing laminitis in heifers may consist of a separate heifer group where animals are acclimated to their new environment allowing for increased resting time and minimized aggression.

Any management practice that imposes stress on animals can deplete the body's nutrient reserves. Stress can reduce the animal's resistance to disease and can be a factor in lameness.

Management practices such as vaccination, transportation, and reduced exercise can impose stress. Nutrition problems such as sudden changes in the ration, low or poor quality fiber, high energy feeding, and mineral and vitamin imbalances can cause stress, especially in early lactation. Disease, pain, and animal aggression can also be factors.

Stall comfort

Adequate stall space should be provided to allow reclining and ruminating for about 10 to 14 hours per day. The dimensions of the stall must be proper for the size of the animal that is being housed. Large cows need a stall length of seven to eight feet. The width can range from 42 to 50 inches depending on the animal size (heifer versus cow). The lower the curb height (not less than six inches), the less chance a cow has of standing in the passageway.

Soft bedding is essential. Sand is an optimal stall bedding, providing cows comfort and traction. In addition, sand must be free of small stones, which can penetrate the sole horn.

An earthen base with shredded tires covered with polyethylene sheets also works in providing a cushioned base.

PREVENTIVE MANAGEMENT, CONT.

However, material must not be of an abrasive nature and must not scrape hocks or knees as cows rise and lie down. The use of sawdust with wood chips on these polyethylene surfaces can be abrasive and cause hock lesions.

Hoof trimming

Regular hoof trimming may increase the functional life of a dairy cow by a lactation. Correctly trimming a cow's feet can give the claw stability and enable the cow to distribute weight equally between the claw.

Routine trimming, which removes even small amounts of the horn from the sole, can stimulate horn production tissues. This can accelerate production of a new healthy horn. It is recommended to trim feet at least once to twice a year. The ideal times would be once at dry-off and again around 100 days in milk.

A professional hoof trimmer who uses correct equipment and procedures should be employed. Good record keeping are key to monitoring a cow's condition.

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TABLES

Table 1. Distribution of digital lesions within a population of cattle.

Description of lesions	Percentage	Description of lesions	Percentage
Sole Ulcer	28.0	Other	4.0
White line disease	22.0	Underrun sole	3.0
Bruising	8.0	Retroarticular abscess	3.0
Digital dermatitis	8.0	Claw deformity	2.0
Interdigital hyperplasis	5.0	Laminitis	1.5
Foot rot	5.0	Interdigital dermatitis	1.0
Foreign body	5.0	Sand crack	0.5
Heel erosion	4.0		

Source: Clarkson et al. An epidemiological study to determine the risk factors of lameness in dairy cows. Univeristy of Liverpool Veterinary Faculty, UK CSA 1370. Final report, 1993.

Table 2. Nutrient guidelines for high producing dairy cattle to prevent lameness.

	Stage of lactation		
	Early [a]	Mid	Late
Crude protein, %DM	17-18	16-17	15-16
Soluble protein, %CP	30-34	32-36	32-38
Degradable protein, %CP	62-66	62-66	62-66
Undegradable protein, %CP [b]	34-38	34-38	34-38
Forage NDF, %DM	21-24	25-26	27-28
Total NDF, %DM	28-32	33-35	36-38
NFC, %DM	32-38	32-38	32-38
Copper, ppm [c]	11-25	11-25	11-25
Zinc, ppm	70-80	70-80	70-80
Vitamin A, IU/lb. DM	3500-4500	3500-4500	3500-4500
Vitamin E, IU/lb. DM	20-30	20-30	20-30

Source: Dairy Reference Manual, NRAES-63.

Table 2. Nutrient guidelines for high producing dairy cattle to prevent lameness, continued.

Note: Table refers to milk production equivalent to a Dairy Herd Improvement rolling herd average of 18,000 pounds of 4 percent fat-corrected milk.

[a] Refers to cows approximately the first 15 weeks of lactation. If cows fresh less than four weeks are kept in a separate group or fed individually, or if laminitis is encountered in first-calf heifers, use the following modified specifications: crude protein, 19%; undegradable intake protein, 38%; forage neutral detergent fiber, 24%; minerals, the higher levels indicated in the table. Dry matter intake during the first month may range from 2.2% body weight at calving to 2.8% body weight at 14 days and 3.3% body weight at 30 days.

[b] Use more than one high-protein ingredient to meet undegradable protein intake needs. Often lysine and sometimes methionine are the most limiting amino acid.

[c] Use the higher copper levels when low-serum copper occurs on rations containing usual levels of 10 to 12 ppm. Induced copper deficiency may result from excessive intake of iron, manganese, molybdenum, and sulfur.

Table 3. Observed forage and TMR particle sizes using the Penn State Separator

	Upper sieve >0.75"	Middle sieve 0.31-0.75"	Bottom pan <0.31"
Corn silage [a]			
	2 to 4% if not sole forage	40 to 50%	40 to 50%
	10 to 15% if chopped and rolled		
Haylage [a]			
	10 to 15% in sealed silo	30 to 40%	40 to 50%
	15 to 25% bunker silo, wetter mixture		
TMR [a]			
	6 to 10% or more	30 to 50%	40 to 60%
	3 to 6% focus on TNDF and FNDF		

[a] Particle size distribution is based on 5,395 observations of corn silage, 6,165 observations of haycrop silage, and 831 observations of TMR.

FIGURES

Figure 1. Cross section of the bovine claw.

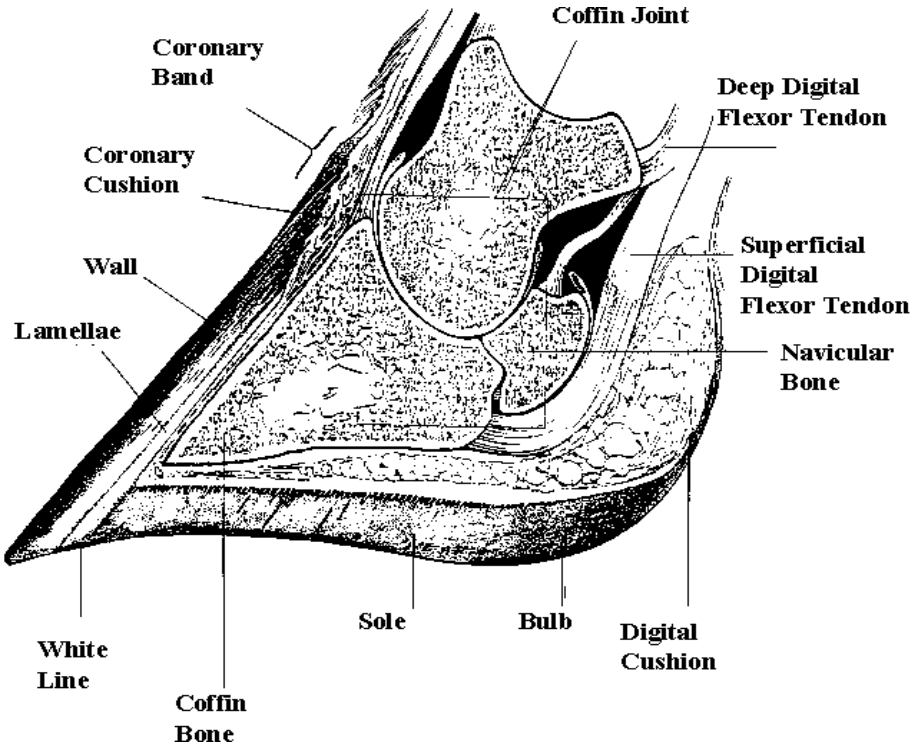

Figure 2. Lameness scoring system.

Lameness Score	Clinical Description	Assessment Criteria
1	Normal	The cow stands and walks with a level back posture. Her gait is normal.
2	Mildly lame	The cow stands with a level back posture, but develops an arched back posture while walking. Her gait is normal.
3	Moderately lame	An arched back posture is evident both while standing and walking. Her gait is affected and is vest described as short striding with one or more limbs.
4	Lame	An arched back posture is always evident and gait is best described as one deliberate step at a time. The cow favors one or more limbs or feet.
5	Severe lameness	The cow additionally demonstrates an inability or extreme reluctance to bear weight on one or more of her limbs or feet.

Source: Sprecher, D. J., D. E. Hostetler and J. B. Kaneene, 1997. A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. Theriogenology. 47:1179-1187.