1 Understand normal foot anatomy to treat and control lameness more effectively

- hooves are made of protein that softens with moisture
- on the outside: the wall, the sole and the heels
- on the inside: the corium and the pedal bone
- hoof design makes it prone to injury in adverse environments

Understanding a normal cow's foot is very important:

- for effective treatment of hoof disorders. (If you had a sore foot, you wouldn't go to a doctor or podiatrist if they didn't know how a normal foot functioned.)
- for consideration of strategies to control and prevent lameness.

1.1 Understand that the claws are made of a hard protein that softens in moisture

The two claws of a cow's foot made of hard protein called *keratin*. It gives the claws their toughness, and protects the cow's foot from daily wear and tear.

The protein of keratin can absorb water. This is important because if hooves are continually wet, the keratin becomes softer, and more easily damaged. For this reason, wetness and moisture can contribute to lameness. Dairy cows living in high rainfall areas, or under intensive conditions such as calving pads and feedlots, can have continually wet and soft hooves.

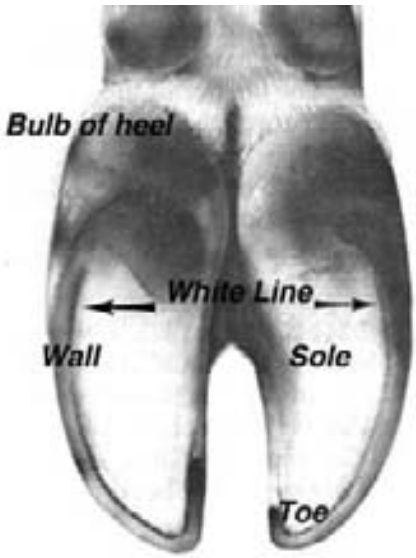
On the other hand, if hooves are continually dry, the keratin becomes very hard, brittle and can crack more easily.

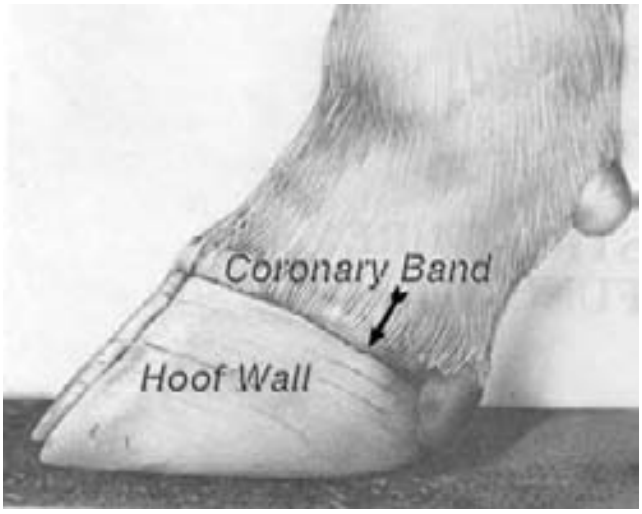
1.2 Recognise the three main parts of the hoof

- The hoof seen from the front or the side view is called the *wall*.

- The hoof that you see from the rear is divided into two *bulbs or heels*, one for each claw. The bulbs or heels are covered in thin skin above the ground, and much thicker hoof material where they contact the ground.

- Lastly, under the foot is the *sole*. A cow bears most of her weight on the wall where it contacts the ground, and the heel, and usually bears very little weight on her soles. Check the hoofprint of a cow made by wet hooves on a dry surface to confirm this fact.





The sole is about 5 mm or ¼ of an inch thick. Despite the fact that it bears little weight, it can still be worn away. For example, if the ground is particularly abrasive, or if the sole is turned or twisted on the ground too frequently, or if cows are walking long distances, the hoof material or keratin is scraped off to the point where the sole is thinned or worn out. Thin soles are more liable to injury or puncture through to the underlying soft tissue.

Soles can also be too thick (especially in older cows with elongated claws). Then the cow bears too much weight on the sole instead of the heel and wall, and this can cause bruising and pressure ulcers.

- The junction between the normal skin above, and the wall and heels beneath is called the *coronet*. The wall grows down from the coronet at ½ to ¾ cm per month, or 8 cm per year.

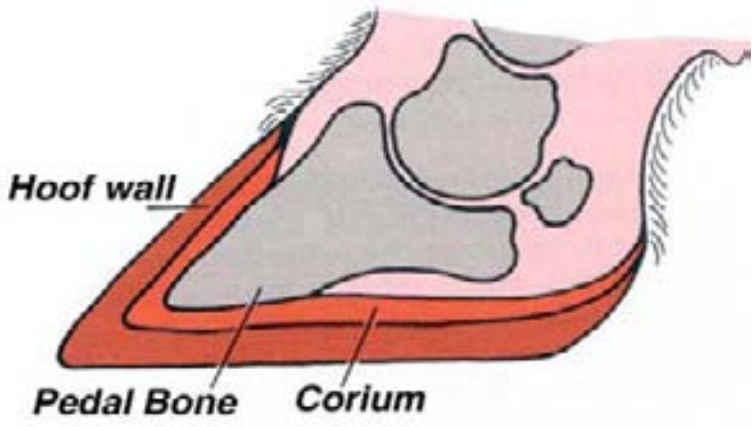
1.3 Gain an understanding of the internal structure of a cow's foot.

- Just beneath the hoof is the area responsible for continually growing new keratin – the *corium*. Fresh keratin is constantly needed to replace hoof material which wears out with daily use. The corium is very rich in blood vessels that supply nutrients required for hoof growth. (Inflammation of this area is called laminitis.)

- It is also rich in nerves that sense the ground surface as a cow walks, and sense pain when the hoof is damaged or diseased.

- Enclosed in a protective layer of hoof, and nourished by blood vessels of the corium is the *pedal bone.* Strands of strong fibres join the hoof and sensitive hoof-growth area directly to the pedal bone. There is also a "cushion" of elastic fibres and fat between the pedal bone and the heels. It protects the sensitive corium from downward

pressure of the pedal bone and upward pressure of uneven surfaces on the sole as the cow walks, absorbing concussion.



- The pedal bone connects with other small bones in the foot. Joints between these bones give the foot flexibility. Tendons link the bones to muscles up the leg, allowing the foot to move forwards and backwards in normal movement.

- Understanding this structure is important for managers wishing to better control lameness. As an example, imagine a cow walking on a sharp stone. The pedal bone presses down with say 140 kilograms (or more) of body weight above it. The sole bends upwards because of the stone under it. This upward flexing is more pronounced if the sole is soft due to excess moisture. The corium is squeezed “between a rock and a hard place” and damaged. A bruise develops in the corium, and because of the nerves in the area, pain, lameness and consequent losses result. Knowledge of this sequence leading to lameness clarifies the importance of such issues as selection of track surfaces, track maintenance and cow handling.

5 How to lift a cow's foot

- always consider safety of the operator
- always consider safety of the cow

Facilities for restraining cows and lifting the front or back feet vary widely in type from farm to farm, and it is beyond the scope of these guidelines to provide hard and fast rules. Crushes and races vary in their ability to provide safe access and thorough examination of cattle feet, and often accessability to the front feet is poor.

5.1 How to lift a front foot.

- Cows can kick well forward with their hindfeet, so when examining a front foot, to avoid facial and head injuries, always rope the hindfoot (on the same side of the animal) first. The foot should be allowed to rest on the ground, but its movement forward should be restricted.
- If the cow is excitable, upset or frightened have an assistant apply a tail-jack, or consider sedation of the cow.
- Fasten a rope to the lame foreleg just above the fetlock, and well below the knee. Use a slipknot or a rope with a loop spliced at one end.
- Pass the rope over a rail at about the level of the cow's elbow, from the inside to the outside of the crush or bale.
- Loop the rope back around the leg at the same level as the original tie.
- Pass the rope over a lower rail at about the level of the cow's knee, from the inside to the outside of the crush or bale.
- Lift the foot, using the two passes of rope as a pulley.
- To make examination possible, bring the foot to the outside of the crush or bale, either above or below a lower rail, and lash it securely to the rail so movement is prevented.

- An alternative approach, which is applicable where cattle are restrained in a head crush, is as follows:

    - An assistant leans against the back end of the cow so as to restrict her ability to kick forward.

- A rope (with a slip knot at the end so that it can form a loop around the leg) is fastened around the fore limb to be examined. The loop is placed midway between the knee and the fetlock.

- The end of the rope is then taken over the cow and around a rail on the other side of the cow.

- The rope is then passed back under the cows “arm-pit” and again back over the rail on the other side. This loop of rope acts a sling to support the cow.

- The assistant (who is still leaning against the back end of the cow) pulls on the end of this rope while the operator lifts the front foot.

- The front foot can then be examined.

It should be realised that in many cases it is more difficult to adequately restrained the front foot of a cow than it is to adequately restrain her the hind foot. In some cases it is safer, and makes for an easier examination of the foot, to cast the cow and restrain her on her side so that the foot can be adequately examined and treated.

5.2 How to lift a back foot.

- Use a slipknot or a rope with a loop spliced at one end. The rope can be fastened to the lame hindleg at one of two sites - either just above the hock, causing pressure on the achilles tendon and so restricting movement, or just above the fetlock so that the foot can be securely lashed to a rail or upright, restricting movement.
- Irrespective of the method of lifting, it is important that subsequent movement is well restricted; otherwise kicking during examination can cause the operator's tools to be knocked, and driven into the operator's hands or other parts of the body, causing injury.
- The rope is then passed over a high rail, back around the leg above the hock, and then back to the same or a lower rail. Pulling on the rope will cause a pulley action. Once the foot is lifted, it is roped to a rail or upright securely so that movement up and down, or forward and backward is very limited.

A loop is placed around the limb to be lifted. The loop is placed just above the hock.

The rope is then taken to a rail above the cow, back down around the hock and up to a rail on the other side.

The operator pulls on the rope to pull back the leg and assistant pulls on the end of the rope which is wrapped around the bar. This lifts the leg off the ground.

A soft rope is then looped around the raised limb, just above the fetlock.

This rope is in placed around the upright as shown.

This rope is then pulled so that the leg can be lashed to the upright bar preventing the cow from movement. This rope continues to be held by the operator so that it can be let go if the cow throws herself to the ground.

The foot is now well restrained so that it can be adequately and safely examined.

- It is preferable that the rope is then held by an assistant rather than tying it up. If the cow slips in the bale or crush, or goes down, it is important that the rope is released quickly to prevent dislocation of the hip.

14 Control moisture and wetness in the cow's environment

- hooves soften with prolonged moisture or wetness
- soft hooves are more prone to lameness
- prolonged moisture or wetness increases the risk of footrot
- construct and maintain milking sheds, yards and tracks to control wetness
- reduce moisture in paddocks

Numerous studies have shown that the risk of lameness increases during and after wet weather. Cattle hooves are made of a protein called keratin, which softens when it absorbs moisture through prolonged wetness. To observe this fact, compare the hardness of hoof material when using a hoof knife to scrape a cow's sole during a long dry period compared to that of a sole exposed to a period of prolonged wetness.

Soft hooves are more prone to lameness:

- They wear more quickly. Increased wear causes thinner soles that are more susceptible to puncture or bruising, and severe wear exposes the sensitive corium at the point of the toe. Worn out toes are a special problem for heifers after their arrival in the herd, and for bulls serving a large number of cows on concrete yards.

- Soft hooves are more easily punctured. For example, the sharp edge of a stone can cut right through a soft sole, and introduce infection to the corium. Because the hoof is soft, but still thick, infection is trapped under the sole and causes an abscess.

- A soft hoof provides less protection against stones or broken concrete, so the sensitive hoof-growth area can be easily bruised.

- A wet, soft hoof is more likely to develop fine cracks along the white line when stressed by turning or being placed on uneven surfaces. The hoof wall can bend away from the sole more readily, allowing the defects and cracks to develop in the white line. These cracks can carry infection to the corium, and lead to foot abscesses.

- In wet conditions, small defects that were present in the hoof and which caused no problem during dry periods provide an avenue for infections to enter the hoof, and this may result in foot abscesses.

Moist conditions also soften the skin between the claws and favour survival of the bacteria which cause footrot, making infection more likely.

14.1 If constructing tracks…

- make sure the surface (or wearing course) prevents seepage of water through to the base. Compact the materials used into a hard, smooth, wear-resistant top. Compacted material should prevent the passage of surface water through into the base material. Cows are not able to compact surface material adequately.

- check the base is above the water table.

- crown the track to help shed water and maintain a relatively smooth surface.

- construct drains outside the fence line to prevent cows walking in the drains. Make sure drains are correctly graded so that water flows away from the track.

An example of a farm track with inadequate drainage

A farm track under construction. Adequate allowance has been made for drainage and the base material is being crowned and compacted using a vibrating roller

14.2 Maintain tracks

- avoid wetting the farm track – leaking troughs, irrigation delvers and irrigation run-off can add moisture to the track and cause the surface to break up.
- if trees or hedges near the track prevent sunlight and wind drying shaded areas, remove them.
- if the surface deteriorates, make sure you reform it when weather permits.
- if grass or manure builds up along the fence line, remove it to allow drainage.

In this section of track the bearing surface has broken away, exposing the underlining base material. This broken section of track can result in foot injury and is in urgent need of repair.

14.3 If constructing milking sheds…

- build a concrete nib wall at the junction of the concrete and track to divert water to side drains. Otherwise, the junction between the concrete and the track is often a wet area because of drainage of rainwater and yard washings onto the track.

- make sure the flow of cows onto the yard and into the shed is unhindered by any unpleasant experience or factor. If cows stop before the junction because conditions in the yard are unfavourable to them, they manure in this area and add to the problem.

- crown, compact and drain the track at the junction with the yard.

14.4 Maintain milking shed yards

- wash the yard twice daily to avoid the build up of slurry.

- make sure yard drainage systems are operational so that cows do not have to stand in water.

- maintain yard concrete surfaces so puddles or water-filled holes do not develop.

14.5 If building calving pads, feed pads and stand-off areas

- check that calving pads, feed pads and stand-off areas are drained correctly, and that drainage water has somewhere to go. Discuss all aspects of drainage with your contractor prior to construction.

14.6 Maintain calving pads and feed pads

- calving pads should be sufficiently dry that no water collects in footprints made with a gumboot.

- scrape feed pads and stand-off areas regularly to prevent the build up of slurry.

14.7 Reduce moisture in paddocks

- elevate troughs and provide a compacted crown for the cows to stand on while drinking.

- fix leaking troughs as soon as possible

- areas around the entrance to paddocks can become worn and retain water. Such areas should be filled in and maintained as required.

- on flat, low-lying farms drainage systems may need to be installed to prevent pasture damage and soft hooves.

An area around a water trough which is in urgent need of repair. Such wet muddy areas will predispose to lameness.

15 Avoid nutritional imbalances

- excess levels of rapidly fermentable carbohydrate leads to laminitis
- subclinical laminitis increases the risk of lameness
- balance high levels of concentrates with adequate levels of fibre
- monitor copper and zinc levels

The effect of excess levels of rapidly fermentable concentrates, especially in the presence of inadequate levels of fibre, is discussed in the Factsheet E, Laminitis (see page XX). Strategies to minimise the risk of laminitis are also outlined in this section.

The trace minerals copper and zinc are both needed by cattle for the production of good quality keratin or hoof material. Good quality hoof material in turn, is required to withstand the wear and tear placed on hooves. However the effect of marginal deficiencies in the level of either mineral is controversial.

15.1 Control the levels of fibre and concentrate in the diet of lactating and dry cows

The following points are guidelines for pasture-based systems.

- If not experienced in feeding high levels of grain, seek the expert advice of a dairy veterinarian, consultant or nutritionist.

- Introduce animals to concentrates slowly. The level of concentrate feeding should be increased gradually – by around 1 kg every second day. Make all feed changes slowly! As a rule of thumb, change no more than 10% of the diet in a four day period.

- If cows are to be fed concentrates immediately after calving, provide a concentrate ration 2 weeks before calving, with cows receiving concentrate up to 0.5 to 0.75% of bodyweight, or 2.5 to 3.7 kgs per cow per day.

- To avoid milk fever, do not feed sodium bicarbonate or legume-based fodders in the late dry period.

- If more than 3 kg of concentrate per cow per day is to be fed, consider using additives such as buffers (for example, limestone or sodium bicarbonate at a rate of one and a half percent) and alkalysing agents (for example, magnesium oxide) to the concentrate portion of the ration. (There is not strong evidence that sodium bicarbonate is effective in cows on pasture.)

Consider using Virginiamycin[1], an additive registered for the control of acidosis in the diet. There may be some benefit from the use of sodium monensin in controlling acidosis, although there is no product claim for this effect.

- At times of lush pasture growth (when the carbohydrate and crude protein content of the pasture is likely to be very high,) it may be necessary to supplement cattle with fibre. This can be supplied by having cereal hay available for the grazing animals.

- Make sure that crushing of grain is not excessive. Grains such as wheat, barley and triticale should be fractured into 2-5 pieces or be rolled. Corn can be broken into 5-7 pieces or be rolled. Production of fine powdered grain increases the risk of acidosis.

- Check feeders during milking to make sure that feed is not building up in them, and that cows are eating consistently.

The following points are guidelines for producers feeding very high levels of concentrates, and those working in near feedlot situations. (Producers should consult their advisor or nutritionist to help formulate a ration that will minimise the risk of rumen acidosis and laminitis.)

- Make sure the minimum fibre and fodder needs are met. Know the NDF (Neutral Detergent Fibre) levels of fodders used.

  For high producing cows, formulate rations to contain at least 23% NDF from fodder. The minimum quantity of fodder as a percentage of dry matter intake should be calculated on hay crop fodder-based rations.

  $$\text{Min. fodder DMI\%} = \frac{23 \times 100}{\text{Fodder NDF}}$$

  This results in a minimum percentage of fodder in the ration dry matter ranging from 65% with low fibre (35% NDF) fodders to 40% with high fibre (55% NDF) fodders. Therefore the minimum quantity of fodder alters according to the percentage of NDF in the fodder, and should be no less than 40 to 45%.

  The total ration NDF should be 27 to 34%.

- Do not exceed 36 to 38% Non Structural Carbohydrate (NSC) in the ration, depending on the grain source.

- If silage is chopped, 25% of the particles on a weight basis should be more than 5 cm long. If silage is chopped too finely, consider feeding 2.5 to 4.5 kg of long or coarsely chopped hay per cow daily.

- Supplement with dietary buffers early in lactation. The recommended feeding rate of sodium bicarbonate is 0.75 to 1% of the total ration dry matter. Sodium bicarbonate is effective for maize silage based diets in providing some control of acidosis.

[1] ®Eskalin.

- Closely monitor changes in fodder moisture content and adjust rations accordingly.
- Do not feed more than 4 kgs of concentrate at one time.
- Ideally, if concentrates and fodders are fed separately, feed concentrates at least three to four times daily.
- Ideally, gradually increase concentrate intake during the first 6 weeks of lactation.
- Consider using Virginiamycin[2], an additive registered for the control of acidosis in the diet. There may be some benefit from the use of sodium monensin in controlling acidosis, although there is no product claim for this effect.

15.2 Control the levels of the essential trace minerals copper and zinc in the diet of lactating and dry cows

- It is advisable to check the existing levels of both these trace minerals in the diet and in the animals themselves, and establish a need for additional quantities, prior to supplementation. Copper is required at the level of 10 mg/kg of Dry Matter in the diet of cattle, and Zinc is required at 40 to 50 mg per kg of Dry Matter.
- Blood test animals to check the levels of copper and zinc. Establish a need for supplementation prior to addition of trace minerals in the diet. In particular, copper has a small margin between recommended levels, and those that are toxic or poisonous. Animals with satisfactory levels of copper may be poisoned with a copper supplement.
- Seek expert advice about when to assess herd copper levels, and about the interpretation of the results of tests. The levels of copper may vary month to month.
- Zinc deficiency has been implicated in lameness in dairy cattle. Zinc is important in claw horn formation and is present in reduced quantities in the horn of cattle with claw lesions. Supplementation with a zinc derivative, zinc methionate, has been demonstrated in several trials to reduce the incidence of hoof abnormalities.

[2] ®Eskalin.

16 Consider the conformation of bulls and cows used for breeding herd replacements

- good conformation reduces the risk of lameness
- breeding for “lameness resistance” a complex issue
- desirable traits may have low heritability

It is well known that the size and shape of an animal – its conformation – has a strong bearing on its ability to remain healthy in its particular environment.

To a certain extent, managers are able to influence the size and shape of their animals as many characteristics are heritable.

Genetic selection or breeding towards a certain shape may make progeny more hardy and resistant to disorders that cause lameness, and therefore less likely to be culled due to foot disease, or infertility or body weight loss related to lameness.

A number of issues add complexity to the goal of breeding “lameness resistant” animals:

- Some desirable traits have a relatively low hertiability.
- Assessing the conformation of animals with consistency and accuracy requires experience and skill.
- Assessment does not necessarily mean measurement, and therefore grading can be subjective.
- Management can affect measurements; for example, claw length can be altered by trimming.
- Foot disorders can affect measurements; for example an episode of laminitis can increase claw length.
- Claw measurements can be affected by age; for example, length may increase with age, and hoof angle may decrease with age.
- Even posture can affect measurements; the way an animal stands may alter scoring.

Further research into this area is required before strong recommendations are made with respect to selection for traits to reduce the incidence of lameness.

The following table[1] is presented as an indication of current opinion regarding traits most likely to affect survivability and to have sufficient heritability (if selected in a breeding program) to result in improvement of progeny.

Trait	*Scoring*	*Desirable*
Claw angle	Low to high	High (>45^o) to 60^o
Rear leg, side view	Posty to sickled	Intermediate
Rear leg, rear view	Close to straight	Straight

In addition, research has indicated that:

- Breeding for production alone may select traits that make an animal more prone to lameness.
- Friesians are more prone to damage than other dairy breeds.
- White or less pigmented hooves (found most commonly in Friesians) are softer and more prone to damage.

16.1 Consider the conformation of bulls and cows used for breeding herd replacements

Do not breed from cows that show marked conformation faults that:

- increase the risk of lameness and
- are sufficiently heritable to result in significant genetic deterioration.

At the time of writing, it is thought that the characteristics most likely to influence the incidence of lameness are:

- Claw angle: Less than 45 ^{o} or higher than 60^o is undesirable. 45 ^{o} to 60^o is desirable.
- Rear leg, side view: Excessively posty or sickled legged is undesirable. Intermediate angulation is desirable. A hock angle of less than 170^o is desirable.
- Rear leg, rear view: Cow hocked or close is undesirable. Straight legged is desirable.

It is a recommendation of the authors that artificial breeding companies investigate the production of an ABV for lameness.

[1] from Lamenes in Cattle (1997), Greenough and Weaver, Saunders.