Historically, extensive dairy cow lameness is a relatively new problem with many causes. As with any complex problem, it takes time to understand its numerous components and develop the correct solution for each. Hoof overgrowth is one component of the lameness problem. Hoof trimming is the practical solution to this, but to be most effective, it must be done correctly.

At the present time, many cows are trimmed incorrectly. An important reason for this is that the current conventional wisdom on trimming teaches that cows should be trimmed according to the precepts of a hoof trimming method that is outmoded. The hoof-trimming method I am referring to is the Dutch method. How this came about and why this is so are the subjects of this article.

The reason for hoof trimming is to prevent and treat lameness. To use an outmoded hoof-trimming method is a hindrance to realizing these goals.

**Hoof trimming methods**

Presently there are three hoof trimming methods: the Dutch method (also called functional hoof trimming), the white-line method and the Kansas method.

The **Dutch method** was developed by Dr. E. Toussaint Raven, a veterinarian who was on the faculty at the University of Utrecht, The Netherlands. It is formally described in the book: *Cattle Footcare and Claw Trimming*, author – E. Toussaint Raven, originally published in Dutch in 1977 with the English edition first published in 1985.

The Dutch method has been further developed by veterinarians: Sarel van Amstel, Frances Palin and Jan Shearer. Their modification is titled *An Adaptation of the Dutch method* and is described in the *Proceedings of the Hoof Trimmers Association Inc. 2002 Hoof Health Conference*.

The **white-line method** was developed by Dr. Roger Blowey, an English veterinarian in private practice at Gloucestershire, United Kingdom. It is formally described in the book *Cattle Lameness and Hoofcare*. There is also a video titled *Footcare in Cattle, Hoof Structure and Trimming*.

The **Kansas method** was developed in the 1950s by Rex Siebert, a professional hoof trimmer and registered Hereford breeder in Marion, Kansas. This method is informally described in several issues of the Hoof Trimmers Association Inc. Newsletter, and normal sole gradient is described in the *Proceedings of the Hoof Trimmers Association Inc. 2005 Hoof Health Conference*.

Dr. Paul Greenough and Raven are the two most widely known pioneer researchers of the bovine hoof. Greenough, currently professor emeritus at the Western College of Veterinary Medicine at the University of Saskatchewan, is the principal author of the book *Lameness in Cattle* which was published in 1972. This was the first comprehensive book written on the anatomy, physiology and pathology of the bovine digit. It is a superb book written primarily for veterinarians; however, a specific method of hoof trimming was not a covered subject.
Raven’s book, by design, is not nearly as comprehensive. It is written for both lay readers and veterinarians focusing on anatomy, the biomechanics of weight bearing, some prevalent pathology, and it was the first book to ever describe a specific hoof trimming method – the Dutch method. Blowey’s book came later. It covers more subjects in greater detail than Raven’s book and is also written for both veterinarians and lay readers. It contains the second written description of a hoof trimming method – the white-line method.

The Dutch method, being the first described, was the only widely known hoof trimming method for many years. As a consequence it was, and is, the most commonly taught, used and cited method. In dairy publications today, most of the information on hoof trimming is based on the Dutch method. Dr. Raven passed away several years ago. In academic circles, his writings remain the most revered authority on almost all matters related to hoof trimming.

Blowey and the memory of Raven have earned respect. In large part, both of their books are excellent, but they are both in error on some very fundamental aspects of normal hoof structure. Specifically, there are two major errors. They do not have a good understanding of normal sole shedding and do not recognize the normal sole gradient of the lifted bovine hoof. These are both basic elements of normal hoof structure. As a consequence, the Dutch and white-line methods both lack comprehensive objective definitions for normal sole thickness and normal hoof structure. These are serious deficiencies because, as will be shown, normal structure is of upmost importance to hoof trimming.

Rex Siebert started trimming hooves in the late 1940s while he was the herdsman of the show barn for the CK Hereford Ranch. Trimming the show string was a part of his work. In 1954 he left CK, started his own herd of registered Herefords and started trimming hooves professionally.

Early on, much of this trimming was on young show and sale cattle that had fairly normal hooves, the trimming being done for cosmetic purposes. He was also trimming many range bulls and by 1960 he was trimming 5,000 head per year, now with many dairymen as clients. The number of head trimmed per year peaked in 1970 at over 6,700 head, the majority now being dairy cows housed in dry lots, tiestall barns and freestall barns. The number and variety of hooves he trimmed early in his career meant that early on Rex saw normal toe structure many thousands of times. Also, since these cattle were maintained in many different housing environments, he was constantly seeing the effects this had on hoof structure. These are some of the reasons Rex was able to grasp an accurate and comprehensive understanding of normal hoof structure. The Kansas method is based on this knowledge. Rex retired from hoof trimming in 2000, having trimmed in excess of 200,000 head of cattle.

As will be shown, due to normal variation, learning the ability to consistently recognize and understand normal hoof structure is not a simple task. It may be important to realize that while it is possible for well-designed research trials to yield accurate results on specific subjects concerning the bovine hoof, it is probably not
possible to design one that would be large enough or general enough to yield accurate results on a subject as all-encompassing as normal structure. There are just too many variations and too many environmental influences. I am afraid that the only way a comprehensive understanding of normal structure can be gained is to work on many thousands of hooves, probably tens of thousands, and in many different environments, or be trained by someone who has.

Blowey and Raven are both accomplished veterinarians. Their biographies are filled with numerous publications in the veterinary literature, and Blowey has authored two additional books of interest to dairymen. However, most of the work experience of Raven, at least during the time of the writing of his book, was on the tiestall or stanchion cow. For neither one was time available to trim a fraction of the number of cows trimmed by a professional hoof trimmer, and being veterinarians, they would spend more time working on diseased hooves than normal hooves. These are likely some of the reasons that account for their deficiencies in recognizing and understanding normal structure.

The importance of normal structure
When considering the anatomy and physiology of the bovine hoof it is axiomatic that normal function is dependent on normal structure. For hoof trimming this means that the most effective way of preventing lameness is making sure that we restore the overgrown hoof to normal structure. To do less will leave the trimmed hoof still in an abnormal state and the result is weakness, dysfunction and more disease.

The stated goals of all three hoof trimming methods are to restore the hoof to normal structure because of the universal recognition that normal structure is the strongest state for the bovine hoof. However, the teachings of the Dutch and white-line methods leave the trimmed hoof with an abnormal structure. Only the Kansas method stays true to the goal of normal structure. To reach this goal, a hoof-trimming method must have a firm grasp of “normal” in its knowledge-base.

In concept, learning to recognize normal may seem straightforward; however, in practice, it is not. Normal is complex and nuanced. The difficulty is that normal is variable - it is not the same from toe to toe or animal to animal. In large part, this is because the bovine hoof is subject to normal biological variation. This is manifested in a multitude of ways.

There are normal variations in hoof structure between animals of the same age, breed and sex. An example of this is the normal variation in heel depth. Some cows are naturally shallow-heeled while others have deeper heels. Normal toe length also varies - some having naturally longer toes while others have shorter toes - and the same goes for toe width. Yet, despite these differences in length, breadth and depth, within a given range, all are normal.

There are also variations between animals of differing ages, breed or sex. One example of age variation would be the normal toe length of a younger animal such as a fresh heifer compared to an older cow. Obviously, the toe length of the heifer
will average less than the cow, but for each of these animals her individual toe length is normal. An example of breed variation would be a comparison of the normal hooves of Jerseys versus Holsteins. The Jersey hooves are smaller and proportionally the toes are usually longer.

Additionally, there are variations between the toes on an individual animal. An example of this is seen in the toes of the rear hoof. Normally the medial (inner) toe will be smaller than the lateral (outer) toe. Another example would be the relative size of the front toes compared to the back toes. Normally the overall size of the front toes, especially in breadth, is larger. In some classes of animals, especially bulls, this will be more pronounced.

These examples are some of the biological variations that affect normal toe structure. There are more, and each can make the normal toe of any given animal physically different in overall size, length depth and breadth from the normal toe of any other given animal and/or from one given toe to another on the same animal. In essence, this means that normal structure is individualized. Within a normal range, each toe has its own normal.

There are two lessons that are worth special emphasis concerning normal structure and hoof disease. Take the example of a naturally shallow-heeled cow that has overgrown hooves. It might be thought that it would help this cow to trim her hooves in a manner that would leave her with a deeper heel. Doing so would be a mistake. Hoof trimming can change the outside of the hoof, but it cannot change the internal structure. In this case, leaving more heel would cause an abnormal orientation between the pedal bone and the ground surface. Abnormalities in this orientation are a base cause of lameness in dairy cows. The lessons are:

1. To best prevent hoof disease each toe must be trimmed to its own normal.
2. If we think we know better than normal, we are in a very precarious position.

In addition to the biological variations, the type of environment a cow is housed in also has a tremendous effect on normal hoof structure. Among other things, environmental variations affect the normal hoof growth/hoof wear cycle by either inhibiting it or allowing it to operate normally. Confinement inhibits this cycle, resulting in increased rates of hoof overgrowth in confined cattle compared to those that are pastured.

The type of housing environment also has an effect on the character of the growth habit of hooves. An example of this is seen when the hooves of tiestall cows are compared to freestall cows. When hoof overgrowth occurs in tiestall cows the toes usually do not deform; they overgrow, but most remain straight. When overgrowth occurs in freestall cows it is common to see the toes deform. This is usually characterized by a twisting, typically to the inside, which is most pronounced in the lateral rear and medial front toes. This difference in growth habit is a consistent finding when hooves of tiestall cows are compared to freestall cows. It is most pronounced when the cows are totally confined.
Normal sole thickness - the key to normal structure
For hoof trimming purposes normal structure has four parameters - wall length, heel depth, sole thickness and sole gradient. To restore normal structure to an overgrown toe, each of these parameters must be trimmed, respectively, to the specific length, depth, thickness and gradient that is normal for that toe.

Due to the myriad of normal and environmental variations affecting hoof structure, developing a practical technique that can identify the true normal of any toe is the daunting challenge of every hoof-trimming method. A characteristic of sole thickness makes this task a little easier because if the specific normal sole thickness of a toe can be established and then the bottom surface of the toe is trimmed to this plane, this one action will also restore each of the remaining parameters to their specific normal. This is shown on the normal hoof in Figure 1* where normal wall length and heel depth are flush at the normal surface of the sole and the sole gradient is parallel with the sole surface. This characteristic narrows the focus of the challenge to a search for a practical technique that can identify the normal sole thickness of any given toe. If this technique can be developed, the individual normal structure of any toe can be determined and the vexing problem of normal variation is solved.

The best type of technique would be one that objectively determined normal sole thickness. The Kansas method has this. The development and explanation of this objective technique are based on an understanding of the biomechanics of the normal hoof growth/hoof wear cycle and normal sole shedding. In particular, there has to be an understanding of the effects different hoof environments have on sole shedding. This information is in the knowledge-base of the Kansas method.

Normal sole shedding
Normally the hoof is a weight-bearing structure that maintains itself. This self-maintenance feature is dependent on the operation of the hoof growth/hoof wear cycle. Sole shedding is a critical component of this cycle. When the cycle is operating normally, hoof growth and wear are in balance yielding an “effective” growth rate of zero. Normal structure is maintained. No hoof trimming is necessary. The growth/wear cycle operates normally when the cow is in her natural environment, which is pasture.

The normal workings of the hoof growth/wear cycle are built into the anatomy and physiology of the toe. The main function of the toe is to carry the cow’s weight. For some very good reasons the majority of this load must be carried by the wall and heel, with the sole carrying a lesser amount. Since they carry most of the load, as a cow moves about, the ground surfaces of the wall and heel are subject to frictional wear. To counter this they continually grow down from the hair line at a normal rate of about a quarter inch per month. Normally growth and wear are in balance. This prevents overgrowth of the wall and heel.

At the sole, things are different. While the sole is also in a constant state of growth, frictional wear plays no part in keeping this in check. At the sole, overgrowth is self-limited because when sole horn grows beyond the sole’s normal thickness it
disintegrates into a white powder and sheds from the surface. This process is called sole shedding, and when it is functioning normally, it constantly maintains the sole at its normal thickness. To summarize, normal frictional wear prevents wall and heel horn overgrowth; normal shedding prevents sole horn overgrowth.

Normally the growth/wear cycle efficiently prevents hoof overgrowth. Normal sole shedding is necessary for this efficiency because by preventing sole horn overgrowth it decreases the amount of growing horn that has to be worn away to just the ground surfaces of the walls and heels. In Figure 2* these surfaces are shaded black. This diagram shows clearly how small the actual amount of this horn is on a normal hoof. With so little horn requiring wear, the workload on the wear side of the cycle is modest so normal frictional wear can efficiently keep up with normal growth. The cycle remains in balance and normal structure is maintained.

**The cause and process of sole horn shedding**

The base cause of sole shedding is the same for every hoof, but there are some details in the shedding process that obfuscate this in the special case where a hoof is subject to extremely low levels of environmental moisture for long periods of time. In this case, the shedding horn is not the typical white powder. Instead, its form might best be described as dried-out whitish shards. (My daughter, Sarah Anne, who has helped me trim thousands of cows, describes this color as “mother of pearl.”) If a hoof is overgrown, these shards are fused together in a mass. This will not break down and shed from the hoof until it is exposed to more normal levels of environmental moisture. This atypical horn will occur in the overgrown front feet of a totally confined tiestall or stanchion cow if the watering bowl is on the front side of the stall curb. In this situation, the front hooves might not see a drop of moisture for months. It is also seen in the overgrown hooves of beef cattle in arid regions if they do not have regular access to a place such as a muddy watering area. An adequate explanation of the special case would require considerable print space. So, for the sake of brevity, the material on sole shedding in the rest of this article, unless otherwise noted, will pertain to cattle housed in all other types of management systems. This would include tiestall and stanchion cows if they are regularly turned out to a place that has a more normal level of environmental moisture.

Basic information on horn structure and foot anatomy is necessary to understand the process of normal sole shedding. Of particular importance is the role played by the microscopic horn tubules.

The horn of the hoof consists of highly modified skin cells with keratin added as a hardening agent. These are arranged in a matrix of tubular horn cells and intertubular horn cells. The tubular cells form the small tubules. These run vertically from the corium (quick) that secretes them to the ground surface of the horn. The intertubular cells fill the space between and around the tubules. Their main function is to glue the structure together.

Figure 3* shows the arrangement of the tubules in the different horns. The wall tubules run from the coronary corium to the wall end, the heel tubules from the heel
corium to the ground surface of the heel, and the sole tubules run from the sole corium to the sole surface. The size of the tubules in Figure 3* is not to scale. In reality, they are very small, and there are thousands of them. A square millimeter is about the size of a pin head. Wall horn averages about 90 tubules per mm2, sole horn averages about 15 per mm2.

Tubules provide structural support and nourishment to hoof horn. Structurally the tubules act like reinforcement rods to strengthen horn. This is a reason why the wall, having so many more tubules per square millimeter, is stronger than the sole. The tubules provide nourishment by transporting it from the corium to the hoof horn. An important element of this nourishment is hydration, so a primary function of the tubules is to transport water to the horn cells.

All the hoof horns lose moisture to a dry environment or absorb moisture from a wet one, but the surfaces of wall and heel horn have a waxy coating that restricts this. Sole horn lacks this waxy layer so its surface readily loses moisture to a dry environment and just as readily absorbs moisture from a wet environment.

The base cause of sole shedding is dehydration. This is borne out by many tens of thousands of individual toe observations. The following is an explanation and description of the process of normal sole shedding.

The sole is a layer of growing hoof horn. Like all other things biological, it has to remain hydrated to retain its structural integrity. Within the depth of this layer the horn cells are hydrated by the tubules. At the point the cells grow beyond the normal sole surface, they dehydrate, and the horn structure disintegrates into the white powder which sheds from the surface. This process takes place continuously as new cells reach the surface, and it appears to be rapid. The continuous nature and speed of the dehydration is probably enhanced by the surface not having the waxy coating. If the Kansas hypothesis, which is listed below, is correct, then the loss of the tubular reinforcement rod effect would also contribute to the rapid structural breakdown and shedding of sole horn.

While the base cause of sole shedding is dehydration, the actual mechanism that causes this dehydration, and causes it to occur precisely at the normal sole surface, is not known. In the horse, the mechanism for sole shedding is known. In Figure 3* the sole tubules are drawn curving back at the sole surface. As is labeled, this is what occurs at the sole surface in the horse. This curving back of the tubules is the mechanism that causes sole shedding in the horse. It works by preventing any further tubular hydration immediately as the cells grow past the normal surface. It is the hypothesis of the Kansas method that the mechanism in the cow is the same as in the horse. The Kansas hypothesis is supported by the following similarities between the bovine and equine hoof, in both: sole horn is tubular in structure, hydration is a function of the tubules, shedding takes place exactly at the normal surface, this surface has no waxy layer, and the disintegrating shedding horn is a white powder.

Three reasons for hoof overgrowth in dairy cows
The balance between growth and wear that prevents hoof overgrowth in pastured cattle is obstructed when normal sole shedding is inhibited and/or when levels of frictional wear are below normal. In most modern dairy systems one, or the other, or both of these are occurring, and there is the additional problem of the dairy ration.

Sole shedding is inhibited when the level of environmental moisture generally exceeds the normal of natural pasture. In most dairy housing systems the total moisture a hoof is exposed to, on a yearly basis, exceeds this. In a system such as a total confinement freestall barn, the level of moisture far exceeds that found on pasture.

The floor of a total confinement freestall barn is always wet. Sole horn readily absorbs environmental moisture. At hoof level, the supply of local moisture is in a constant and steady enough supply to keep the sole horn cells hydrated even as they grow beyond the normal surface. By preventing cellular dehydration, local moisture short-circuits the shedding process and the result is the overgrowth of environmentally-hydrated sole horn across the entire sole surface. Figure 2* showed that on the bottom of a normal hoof, the surface area requiring frictional wear was relatively small, just the blackened areas. When sole shedding is completely inhibited, that blackened area, which would now include the sole horn, increases to cover the entire bottom surface of the hoof. This is almost a tripling of the horn surface that will require frictional wear. Available wear cannot keep up with the growth of this increased amount of horn. The result is hoof overgrowth. In other systems with less confinement, some level of dehydration and shedding takes place. This results in the overgrowth of less environmentally hydrated sole horn, but in most cases, it will be more than available wear can check. Again, the result is hoof overgrowth.

As previously mentioned, the actual force of hoof wear is friction. Confined dairy cows do not walk as much as cows on pasture. This reduces frictional wear to below-normal levels in most confinement systems. The exception would be sand-bedded freestall barns where the grit in the alleyways is more abrasive than the floor of pasture. This partially mitigates the effect of less-than-normal exercise, but the increase in the wear requirement, from reduced normal shedding, is usually high enough that the net result is still hoof overgrowth.

It is reported that wet concrete is more abrasive than dry concrete. Frankly, this is not believable, at least as it pertains to the situation in dairy housing. If you are moving quickly down an alleyway and have to make a hard turn at a cross alley, would you rather make that on a dry floor or a wet one? Slippery mean less abrasive and less frictional wear. It is very probable that this is an additional reason why high levels of environmental moisture result in hoof overgrowth.

A dairy ration is higher in energy and protein than pasture grass. This increases the growth rate of the hoof.

These three factors are major causes of the hoof overgrowth problem. All modern
dairies will have at least two (the ration factor plus one more). Many have all three: a hoof growth rate higher than normal, a hoof wear rate lower than normal and an above-normal requirement for wear (reduced sole shedding). Each of these rolls the balance to the growth side of the cycle.

Restoring normal structure, by correct hoof trimming, is the most effective practical solution to this problem and its herd health consequences.

Normal sole thickness is the most important aspect of correct hoof trimming because, as previously explained, if the bottom surface of an overgrown toe is trimmed to the plane of normal sole thickness, this restores normal structure to the entire toe. Put simply, if the sole is trimmed to normal thickness, the hoof trimming is correct; if not, it is mediocre.

The theories of all three hoof trimming methods recognize the importance of normal sole thickness. But what exactly is ‘normal’ sole thickness? How is this gauged during the hoof-trimming process? These two questions would also apply to ‘normal’ structure. They are the crux of hoof trimming.

The hoof-trimming methods have each developed means to satisfy these questions. The Dutch and white-line methods do this subjectively; the Kansas method does this objectively. The latter is more accurate and will be explained first.

**Comprehensive objective definitions for normal structure**

An effective way of overcoming the problem of normal variation would be the development of objective definitions for normal structure that would always be able to precisely state what ‘normal’ structure is. They would have to be comprehensive enough to include all possible variations of normal!

These definitions have been developed from information in the knowledge-base of the Kansas method; of particular importance is the information on sole shedding. The definitions state important facts about normal structure. Their utility will become apparent as they are used in the explanation of how hooves are objectively restored to normal structure. They are listed below with some comments. These definitions will precisely describe the normal structure of any given toe – whether it be the rear toe of a 400-pound heifer or the front toe of a 2,600-pound bull.

Two of the technical terms in the definitions may seem awkward if they are not a part of your everyday language. They are used because they increase the precision of the definitions. Defining these terms may be helpful:

- **Distal** – remote, farther from any point of reference. Example: The hoof is distal to the pastern joint (in this case, the implied point of reference is the main part of the body of the cow, the hoof is farther from this than the pastern joint, so it is distal to the pastern).

- **Proximal** – means closer to any point of reference. Example: The dew claws are proximal to the toes (same implied point of reference).
Objective definitions for the components of normal hoof structure:

1) Normal sole thickness – For any given toe, this is the depth of the tubular-hydrated sole horn. This definition answers the question: What exactly is ‘normal’ sole thickness?

2) Normal sole surface – For any given toe, this is the distal extent of tubular-hydrated sole horn. When this definition is combined with definition 1, together they state: That the normal sole surface is the ventral surface of the sole when it is at normal thickness. This is a very important fact for trimming all hooves because if an overgrown toe is trimmed to its normal sole surface this means the sole will be at its normal thickness.

3) Tubular hydrated sole horn – For any given toe, this is the sole horn proximal to the normal sole surface. When this definition is combined with definition 1, they state that: All normal sole horn is tubular hydrated, and it can only occur above (proximal to) the normal sole surface.

4) Environmentally hydrated sole horn – For any given toe, this is the sole horn distal to the normal sole surface. This definition describes the overgrown sole horn that retained its structural integrity by absorbing local moisture. When this definition is combined with definition 3, they state that: All sole horn that is environmentally hydrated is abnormal, and it can only occur below (distal to) the normal sole surface. These are important facts for trimming hooves when sole shedding is restricted.

The objective definitions for the individual components of normal structure make it possible to derive a comprehensive objective definition for the whole of normal structure.

5) Normal toe structure – For any given toe, this is the distal extent of the wall and heel at the plane of the normal sole surface. This answers the question: What exactly is ‘normal’ toe structure? Also, this definition could be stated in another way that would re-emphasize what has been written previously about the importance of normal sole thickness to normal structure. The re-stated version would be: For any given toe, normal toe structure is the bottom surface at the plane of normal sole thickness.

When the two definitions for normal structure are combined they teach a summary of how normal structure can be objectively restored to any given overgrown toe. Combined, they state that: Normal structure is restored if the entire bottom surface is trimmed to the plane of normal sole thickness, and in practical terms, this is accomplished by trimming the entire bottom surface to the plane of the normal sole surface.

The sole interpretation technique of the Kansas method

This section is a description of the basic principles of the sole interpretation technique of the Kansas method.
The sole interpretation technique of the Kansas method will objectively restore an overgrown hoof to its normal structure. Of particular importance to the accuracy of this technique are the unique structural characteristics of environmentally hydrated sole horn and the various fill levels of the sole hollow of the overgrown toe.

Environmentally hydrated sole horn is abnormal because of its location and structural differences, when compared to normal sole horn. (“Environmentally hydrated sole horn” is a long label. For the sake of brevity, and since by definition this sole horn is abnormal, for the rest of this article the term “abnormal sole horn” will replace the term “environmentally hydrated sole horn.”) The local environmental moisture that supplies hydration to this abnormal sole horn is usually not in enough supply to keep the entire structure of this overgrown horn hydrated. As a result, most abnormal sole horn will contain varying amounts of the white powdery residue of dehydration. (Rex Siebert calls the white powdery residue “pith.” This is the term that will be used for the rest of this article.) The pith is interspersed in the structure of abnormal sole horn in pockets. The number and size of these pockets of pith is determined by the supply of local moisture. Higher levels of this moisture increasingly restricts dehydration, which decreases the number and size of the pockets. Lower levels result in more dehydration which increases both their number and size. In the toe of a totally confined freestall cow, the majority of the pith is usually located in the upper half of the abnormal sole horn, with the heaviest concentration just below the normal sole surface. In freestall cows that have free access to sun-dried concrete and/or dirt, and in cows on dry lot, the pith is interspersed throughout the structure of the abnormal sole horn. The structure of the abnormal sole horn surrounding the pockets of pith has exactly the same appearance as normal sole horn. The presence of pith is important for the correct trimming of most dairy cow hooves.

When hoof overgrowth occurs, there is always wall and heel overgrowth. Sole horn overgrowth depends on the status of sole shedding.

Figures 4* and 5* show two hooves – one with moderate overgrowth and one with severe. In both, there is no sole horn overgrowth. The space between the overgrown walls and heel of a toe is called the sole hollow. Its top is the normal sole surface. The space of the sole hollow is empty, partially filled, or completely filled with abnormal sole horn depending on the amount of sole shedding. When sole shedding is inhibited the sole hollow will contain various amounts of abnormal sole horn growing from the normal sole surface. The amount of this growth depends on the degree of inhibition. When sole shedding is severely inhibited, the sole hollow will be filled completely with growing abnormal sole horn. Lesser degrees of inhibition result in progressively smaller amounts of fill. When sole shedding is normal, the sole hollow is empty. This is depicted in Figures 4* and 5*.

Usually a hoof will never reach the stage of overgrowth depicted in Figure 5*, if its sole hollow is empty. Without the lateral support provided by a filled sole hollow, the wall of each toe would fatigue and break off at its base around the margin of the normal sole surface, before it reached this severe stage of overgrowth. This amount of overgrowth, with an empty sole hollow, is seen, but only in the overgrown hooves
of previously confined cows several months after they have been turned out to pasture. The time on pasture restores normal sole shedding. This empties the sole hollow of the abnormal sole horn that grew during confinement. This emptying is described as the “shelling out” of the sole hollow. If these hooves are not trimmed in time, the walls will break off as described. This is Mother Nature’s method of hoof trimming, but sometimes her technique is not the best. The toe walls can break off too short and lameness results.

The sole interpretation technique of the Kansas method provides the means to identify when the normal sole surface has been reached during hoof trimming. Since the normal sole surface is the ventral surface of the sole, when it is at normal thickness, by definition, normal toe structure is objectively restored to any given toe by identifying the normal sole surface and trimming the entire bottom surface to this plane. The location of the normal sole surface is gauged in two ways. When the sole hollow is empty, the location of the normal sole surface is identified visually. When the sole hollow is partially or completely filled, the location of the normal sole surface is determined by sole interpretation. The sole hollows in the Figure 4* and 5* hooves are empty so the location of the normal sole surface is visually identified. Trimming these types of hooves is relatively simple because the whole normal sole surface can be seen during the entire process. Hoof trimming would consist of removing all overgrown wall and heel horn flush to the level of the exposed normal sole surface. Bill Mink, a hoof trimming acquaintance from Virginia, calls this a “rim trim.” This objectively restores normal structure because, by definition, the entire bottom surface is now at the plane of normal sole thickness. Dairy cows that spend much of their time in dry lots, where sole drying might be sufficient to cause normal sole shedding, can have hooves like Figure 4*, and as mentioned above, some pastured cows will have hooves like Figure 5*.

In most dairy cow hooves, the sole hollow is partially or completely filled with growing abnormal sole horn. Figure 6* is a transverse section of an overgrown hoof where the sole hollow is completely filled. The normal sole surface is underneath the overlaying abnormal sole horn. This hides the normal sole surface so its exact location must be ascertained during hoof trimming by the process of sole interpretation. The following is a description of the basic elements of this process. Figure 6* shows that the pith is dispersed in the abnormal sole horn in pockets. There is never pith in the normal sole horn because of the hydration supplied by the sole tubules. This characteristic of pith, that it is found in abnormal sole horn but is never found in normal sole horn, is used to locate the interface between these two layers. This is done by trimming the bottom of the hoof to just short of the complete disappearance of pith on the surface of the trimming cuts. When this is accomplished across the entire expanse of the newly cut surface, this establishes the plane of the interface between the normal and abnormal sole horns. This objectively restores normal structure because this interface is the normal sole surface. This process of interpreting the sole is also called ‘reading the pith.’ It will work to restore normal structure, with the same efficiency, whether the sole hollow is partially or completely filled. It can be used any time that enough sole drying is taking place to result in the production of at least some pith.
Normal sole gradient

Normal sole gradient is represented by the dashed lines in Figure 1* and by the thick dashed lines in the picture of the hoof in Plate 1*. When weight bearing is removed from a hoof (as when it is lifted for trimming), the normal sole surfaces of the toes slope upward and inward at a normal gradient that averages 3 to 4 degrees from a line perpendicular to the cannon bone. (This inward cant is analogous to what happens to the front wheels of a car when it is raised by its frame on a lift.) This 3 to 4 degrees is an estimated average. The actual plane of the gradient that is normal, for any given lifted hoof, is established by the plane of the normal sole surfaces and will be parallel to them. It may be important to note that normal gradient is only seen clearly on a correctly trimmed hoof, a normal hoof or a very near normal hoof. Anything more than a slight amount of sole horn overgrowth will distort it.

The hoof in Plate 1* was a rim trim. All that had to be done to restore normal structure was to remove the overgrown wall and heel horn. Where this was removed is shown by the fresh cut surfaces around the perimeters of the toes. The soles were not trimmed because normal sole shedding has maintained them at the thickness that is normal for this hoof. Actually, this hoof is not completely trimmed. I use an electric sander to finish the hoof, but on this hoof the sanding will be minor, primarily cosmetic. This picture shows clearly that normal sole gradient is parallel to the normal sole surfaces. This is also a good example of normal variation because this cow’s true normal, for sole gradient, is a little more than the average 3 to 4 degrees.

When a hoof is trimmed objectively to normal sole thickness, this, in a sense, automatically takes care of normal sole gradient because the bottom surfaces will be at the gradient that is normal for that hoof. When trimming a hoof with a filled sole hollow that has no pith, normal sole thickness must be determined subjectively. This manner of trimming cannot reveal the true plane of normal sole thickness, so normal gradient is not automatic. In this situation, it is important to make a point of trimming the bottom surfaces to a 4-degree gradient, in the hope that this will be close to the gradient that is normal for the hoof being trimmed.

There are some very important reasons to make sure hooves are trimmed as close as possible to their normal sole gradient. Lack of space prevents a complete listing of these, but a glance at Plate 1* will illustrate one of the problems that can develop when normal sole gradient is ignored. In the Dutch method, the soles are not trimmed to normal gradient, instead it is required that they be trimmed flat, (perpendicular to the cannon bone, this plane of trim is illustrated by the thin dashed lines in Plate 1*). The normal sole in an adult female bovine averages a little more than a quarter of an inch in thickness. The soles of the Plate 1* hoof are at normal thickness. If this hoof would have been trimmed flat, as required in the Dutch method, (again, illustrated by the thin dashed lines), what thickness would the soles have along their outside edges? They would be left very thin. This would be a serious error. It would make this hoof much more vulnerable to a white-line infection. This type of infection is the second-most common cause of lameness in dairy cows due to toe disease.
Subjective hoof trimming methods
The Dutch and white-line methods use average values for toe length and heel depth to subjectively determine sole thickness.

In the Dutch method, 3 inches is considered the average toe length for an adult Holstein cow. This length is measured on the dorsal wall. (This goes from the hairline to the toe tip.) The toe is reduced to this length and the anterior bottom surface is trimmed to leave a quarter-inch vertical step at the toe tip. This determines the trimmed anterior sole thickness. The average heel depth is considered to be 1.5 inches; this is estimated, and the posterior bottom surface is reduced to this depth. This determines the trimmed thickness of the posterior sole. The soles are trimmed flat (perpendicular to the cannon bone).

In the white-line method 3.25 inches is considered the average toe length for the use of this method (personal communication). The toe is reduced to this length, and the bottom anterior surface is trimmed until the white line reconnects on the trimmed surface. This determines the trimmed thickness of the anterior sole. At the heel, Blowey mentions no specific heel depth, but on the back feet the heel of the inner claw is used as a guide to determine proper heel depth. The soles are trimmed flat, same as in the Dutch method.

As previously noted, normal toe length and heel depth are both subject to normal variation. The normal range of toe length for an adult cow has been determined. Blowey’s book lists a range of from 60 mm to 80 mm (2.38 to 3.13 inches). Raven’s book does not list a specific range but he writes, “Normal wall length (toe length) is best defined as the range between too short and too long.” The normal range for heel depth has also been determined. Blowey’s book lists a range of from 25 mm to 35 mm (1 to 1.38 inches) for young cows, and 30 mm to 45 mm (1.25 to 1.75 inches) for older animals.

When the cow being trimmed has a normal toe length that does not match the 3 inches used in the Dutch method, or 3.25 inches used in the white-line method, then her trimmed anterior sole thickness will not be her normal sole thickness. If her normal toe length is less than average, these methods both leave her anterior sole thicker than normal; if more than average, her anterior sole will be trimmed thinner than normal. Since heel depth is also variable, the same problems can occur with sole thickness in the posterior half of the sole. These have been descriptions of sources for error along the length of the sole. Another source for error in thickness, this time across the width of the sole, results from trimming the soles flat. This error, and one of the problems associated with it, was described in the previous section.

Using average values means the problem of normal variation remains and the trimmed structure may or may not be the normal for the hoof being trimmed.

For the most part, the information in Raven and Blowey’s books is good. Blowey’s book has special worth for anyone interested in cow hooves. It contains detailed information on internal anatomy, how this relates to pathology, a substantially
complete listing and explanation of hoof diseases, effective treatments for lameness and explanations of many husbandry practices that will promote healthy hooves. But in both books the information on hoof trimming is lacking, and in Raven’s book there is an error in his explanation for the cause of sole ulcers. The hoof overgrowth cause that he gives cannot be applied to the hooves of freestall cows, nor can the corrective trimming he suggests for this lesion.

The sole ulcer is the most common cause of lameness in dairy cows due to toe disease. The base cause of this error, and the other errors relating to hoof trimming, are due to a lack of a good understanding of normal structure. Specifically, these books contain almost no information on normal sole shedding. Blowey’s book has three sentences that pertain to it in an abstract way. Raven’s book has four, but they are a little more relevant. There are no objective definitions for normal structure. Normal sole gradient is not mentioned in either book. As previously mentioned, these deficiencies are simply the result of not seeing enough total hooves, in enough different environments, to get a firm grasp of normal structure.

As previously written, most of the recommendations about hoof trimming technique that are written in dairy publications go back to the Dutch method. The recommendation to trim the soles flat is seen often in articles about hoof trimming. If this recommendation is used, for all practical purposes, every trimmed hoof will be left with an abnormal structure. Some other examples of recently published recommendations that will result in abnormal structure are that the sole should never be left with a concave surface, that the heel of the inner rear claw must never be trimmed down, that no portion of the inner wall at the end of the toe should ever be removed.

Conclusions

As a veterinarian, I devote about three-quarters of my practice time to working on cow hooves. Most of this work consists of hoof trimming. At the present time, the majority of the cows I trim are housed in freestall barns. On most of these dairies, the lactating cows have at least some seasonal free access to dirt or sun-dried concrete. (The dry cows all do.) In these environments, there is usually enough sole drying to allow the use of the Kansas method on almost all of the cows.

I also trim on dairies where the lactating cows are housed in total confinement freestall barns. On all of these dairies, the dry cows have free access to dirt, sun-dried concrete or are on pasture. Whether or not there is sufficient sole drying to allow the use of the Kansas method on a lactating cow will depend on how long she has been fresh.

I use the Kansas method because its knowledge-base and objective technique result in a hoof that is accurately trimmed to normal structure. If insufficient sole drying results in no pith, a subjective technique very similar to the Dutch method must be used, except instead of trimming the soles flat, they are trimmed to the average normal gradient.

In my opinion, as they are now taught, the subjective Dutch and white-line methods
are outmoded for use on most dairy cows. Their use of average values to determine normal sole thickness is inherently inaccurate compared to the objective technique of the Kansas method. Additionally, the Dutch and white-line methods require that the soles be trimmed flat. This will almost always result in a hoof trimmed to abnormal structure. When insufficient sole drying requires the use of either of these two methods, they should be modified to ensure average normal gradient in the trimmed hoof. To do otherwise will result in abnormal structure.

Dairy cow lameness is a serious problem. It has both economic and animal welfare consequences. The purpose of hoof trimming is to prevent and treat lameness. To leave the trimmed hoof with abnormal structure defeats this purpose. PD

References omitted but are available upon request at editor@progressivedairy.com

Plate and Figures omitted but are available upon request to editor@progressivedairy.com.

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