Inadequate thickness of the weight-bearing surface of claws in ruminants

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ABSTRACT

The term 'thin soles' refers to the suboptimal thickness of the weight-bearing surface of claws in ruminants. These palmar/plantar surfaces of the claws support the weight of the animal and consist of the distal wall horn, the sole proper, the heel and the minute white line area. The sole should normally only bear weight on uneven or undulating surfaces. A decrease in the thickness of the weight-bearing claw surface will decrease the protective function of this structure and may alter the proportion of weight-bearing by each section with possible detrimental effects on hoof function. Horn tissue readily absorbs water and becomes softer which can lead to increased wear rates. Growth rates normally match wear rates but, unlike the latter, time is needed for the growth rate response to adapt to changes in wear rate. Concrete surfaces can be abrasive and dairy cows that spend their lactation cycle on these floors should be let out to pasture in the dry period so that their claws can recoup lost horn. Frictional coefficient is a measure of the 'slipperiness' of hooves on various surfaces. Newly laid or fresh concrete is not only abrasive but the thin surface suspension of calcium hydroxide that forms has a very alkaline pH which causes keratin degradation and is mostly responsible for the excessive claw wear that occurs. Four case studies are used to illustrate the importance of the distal wall horn, the dangers of over-trimming and the effects of disease and concrete on horn growth and wear rates.

Keywords: concrete, distal wall horn, frictional coefficient, growth rate, wear rate, weight-bearing surface.

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INTRODUCTION

The sole and heel bulb account for the largest area of the weight-bearing surface of the ruminant claw while the equally important distal portion of the claw wall occupies the rest. The cow's weight, which determines the loading forces to each limb, is transmitted down the central axial core of each limb. These forces are all concentrated at phalanx 3 (P_3), which then disperses them to the claw capsule, which in turn distributes the load to the weight-bearing surface of the claw.

The most effective way to support large forces is through the outer circumferential ring of a hollow cylinder. The long limb bones are a typical example. The walls of the 2 claws of each limb basically form a hollow cylindrical shape with which to carry the large forces transmitted down the limb. Attachment of P_3 to this cylindrical claw capsule is *via* a suspension mechanism provided by the laminar corium. This suspension is predominantly from the dorsal and abaxial claw walls and it supports most of the animals' weight. A relatively large surface area is required for this function, which is provided by the claw circumference and the claw length (usually around 7.5 cm in a Friesland cow)[8,16,20]. The claw wall is the hardest and strongest horn and is specifically built to support and transfer this load onto the ground. The distal phalanx (P_3) can vary in size and shape; however, the solar surface of this bone is approximately equal in area to that occupied by the bony fissures on the lower dorsal and abaxial side walls of P_3 created by the laminar dermal attachments. This would imply that the sole and laminar corium should bear equal weight. However, the extensive horn lamellae and corresponding interdigitating dermal laminae (±1300/claw) considerably increase its surface area (>600 % in horses), the function of which is to take most of the weight and hence reduce the load on the sole[8,13]. For this reason the distal wall should protrude slightly beyond the solar surface on a normal claw, as the wall is the main weight-bearing surface of the claw[3,13,16,21].

The contention that this is the natural shape and function of the claw is supported by the fact that this is the shape predominantly seen in younger ruminants and those older animals that are not extensively accommodated on concrete[2]. Even if the ventral claw surface was flat, the weight borne by the various segments of the claw would not be proportional to their respective surface areas owing to the differing consistencies of the horn types that make up this surface.

The natural sole should normally be concave as viewed from below and should slope upwards towards the interdigital cleft. Therefore on a flat surface very little sole should be in contact with the floor and very little weight, if any, should be born by the ventral sole. It is only on uneven and or yielding surfaces that the normal sole will take any downward weight. Wear to the sole should be minimal and therefore the average thickness of the ventral sole area (region 5) should not be less than 5 mm to 7 mm thick[8,16]. The dorsal wall length appears to be correlated to sole toe thickness and in Friesland cows a dorsal wall length of 7.5 cm has a sole toe thickness of ± 8.2 mm[20].

The bulb in ruminants is part of the weight-bearing area and plays a significant role in transferring and distributing forces from the limb to the surface. The heel experiences large forces especially on initial contact of the claw (heel strike in the step cycle) with forward motion (>2 times that when standing)[21]. This sudden impact with its forward kinetic energy needs dampening or cushioning and is accommodated by the softer, less rigid heel horn, which is generously sprung by underlying digital fat cushions[8,16]. With this heavy usage, wear and tear will be relatively fast on this softer horn, hence the need for a faster growth rate and increased horn thickness (±15 mm) relative to the sole[8]. At push off in the step cycle, all the developing kinetic energy is needed for propulsion and therefore a non-cushioned, strong wall horn is ideal[21].

If the weight-bearing claw surface is worn flat the sole will bear more weight and will consequently wear faster. Thinning of the sole exposes softer, immature horn that wears even faster, exacerbated

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by the slower growth rate of the sole, it may become pathologically too thin. The hinge-like property of the white line will cause the sole to retract slightly and therefore transfer some weight back to the distal wall.

Claws are subject to continuous change with regard to horn tissue quality, rate of horn formation and loss, all of which are important for problem-free mobility. The likelihood that a cow may suffer from claw lesions and claw pathology is determined by claw horn quality, load dynamics and environmental factors.

Load dynamics can be altered by changing the claw shape which, apart from being genetically determined, can also occur due to various pathological conditions and faulty trimming. Animals housed extensively on concrete floors have a change in claw shape, with the claws becoming higher and or exhibiting decreased claw angles, probably due to increased wear and tear[21].

The Dutch method of functional hoof trimming is intended to achieve a flat weight-bearing area to provide a maximum supportive area to induce overall lower horn pressures[18]. It undoubtedly does this but at the expense of increasing pressure on the solar corium and less on the wall, which appears to be contrary to the natural supporting mechanisms, and therefore this method has been seriously questioned[2,21]. Trimming by this method does increase contact area with a concomitant decrease of average claw pressure by ±30 % and also shifts some pressure from the lateral hind (±10 %) to the medial claw[21]. However, these pressures are still concentrated at the sole and bulb area and the high maximal pressures experienced by the claws after trimming, which are more likely to lead to horn fractures, were the same as before trimming[21].

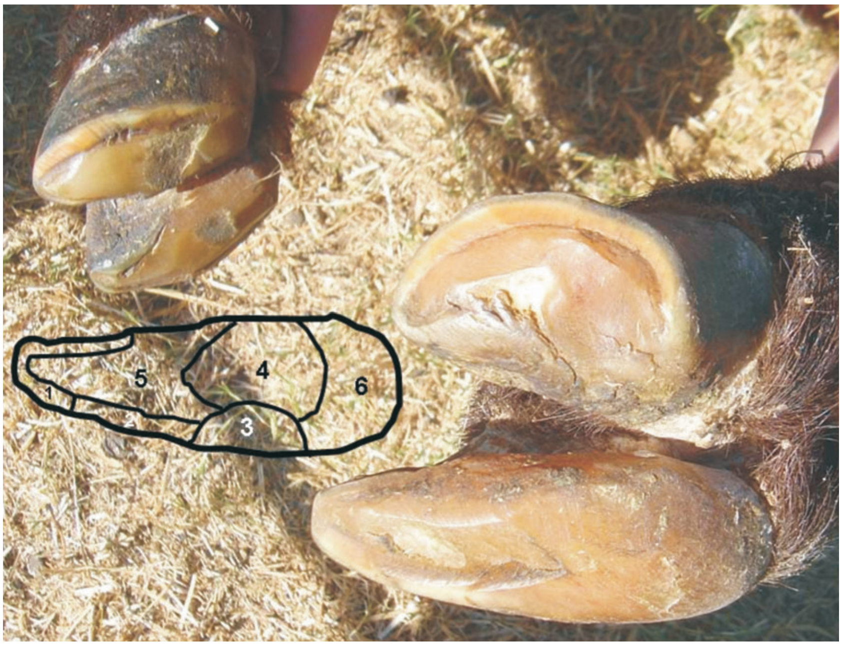

Fig. 1: **The front and hind right claws of a Kalahari red goat illustrating the excessive wall horn removal . The solar surface is now the major weight-bearing surface. The diagrammatic outline illustrates the zones of the weight-bearing surface of a claw.**

Case 1

A 104-kilogram Kalahari red male goat was presented to the clinic with a complaint of lying down frequently, reluctance to stand and a walking gingerly. His owner had recently trimmed all his claws by removing the side walls (Fig. 1). In places the wall had been removed for ±1 cm above the solar surface. The animal was walking entirely on solar and bulbar horn, which was still very thick. The solar corium would be experiencing excessive weight and bruising in the deeper, immature horn layers was likely and probably the cause of the tenderness that the goat felt on deep palpation of the weight-bearing surface. The solar and bulbar weight-bearing surface was left intact, as any paring would expose softer, immature horn that would wear that much more rapidly as this area was bearing all the limb load owing to the lack of wall horn support. Assuming a growth rate of ±5 mm/month it would take between 1 and 2 months before the wall could assume its normal weight-bearing function.

CLAW HARDNESS

Resistance of the claw horn to environmental effects depends on horn quality, in particular hardness, which negatively influences wear rate and attrition[5,22]. Nutrition, lactation, age, blood supply and season also affect horn quality and hardness[4,5,16].

There are marked differences in hardness between the various claw regions, with the dorsal wall being the hardest and the heel–sole junction the softest[5,16]. The toe area of the abaxial wall has a similar degree of hardness to the mid-wall region, whereas the sole horn is close to 40 % softer[10.21]. The sole is harder than the heel horn and is therefore also more resilient [9]. Hardness is determined by the number of horn tubules per unit area of horn, the ratio of medulla to cortex of these tubules and the amount and quality of the intertubular horn[5,16]. Fatty acids and biotin (owing to its role in lipid metabolism) are required in the synthesis of intercellular cementing substances that connect horn cells[5,12,14]. Strength and rigidity vary in the claw wall, sole and heel owing to different lipids and different concentrations of these lipids that make up the extracellular matrix in these areas[13]. This lipid variation within the claw capsule sections has an effect on moisture uptake since lipids are hydrophobic. The solar horn has a greater concentration of total lipids than the wall area[5,11]. Other substances like methionine and cysteine may also play a role in determining horn hardness, as these sulphur-containing amino acids in keratin fibres provide flexibility[13].

Claws absorb water rapidly[4,5,9]. Within an hour claws can absorb 30 %, and within 4 hours, 50 % of the water absorbed over 24 hours[5]. Claw horn can absorb 1.6 g of water/100 g of claw horn within 24 hours and total claw saturation can reach 32 %[4,20]. Bovine hoof keratin behaves like a hydrophilic gel and swells as it takes up moisture[9]. Keratin is more likely to abrade and become less dense as it uncoils when in a swollen, hydrated state[4,9]. Swollen keratin leads to softening and loss of structural integrity, which leads to weakening of the horn so that it not only wears faster, leading to less protection of the underlying tissues (especially solar corium), but the horn becomes prone to damage by hydraulic rupture when it experiences impacts or suddenly has to bear weight[4,9]. As claw tissue absorbs water its hardness decreases proportionally (average hardness throughout the claw decreases by 12 %) and the claw becomes softer[5,22]. The immediate softening actions of rainwater were measured at 26 % relative to the softening that developed over 72 hours[9]. The effect of hydration will also affect toughness, elasticity and resilience of the hoof material[4,22].

The base of the wall horn (zones 1, 2 and 3) undergoes the largest and earliest changes in hardness (12 % decrease in hardness over 4 hours) while the sole (zones 4 and 5) softens more slowly and steadily (4 % decrease over 4 hours and up to 20 % over 72 hours) and the abaxial mid wall experiences the least dramatic changes[4,5,20]. With hydration, therefore, the weight-bearing surface of the wall base changes and loses resilience most rapidly and, because it takes the most weight and experiences the most abrasive forces it will wear relatively faster than the other areas, possibly becoming level with the solar surface and exposing it to the potential problems created by weight-bearing .

Solar horn of the rear claws has significantly higher moisture content than the front claws[20]. Reasons given are that the front claws have thicker soles and that the rear claws are more exposed to the wet alleyways and to the areas with the higher concentration of manure and urine. This higher moisture content of rear claws will make the rear feet more prone to increased wear. 'Thin sole' cows have up to 21 % more moisture content than normal cows under the same conditions, probably because the thinner soles have more immature horn exposed, which naturally has a higher water content[20]. This immature horn will wear faster.

Rainwater, urine and slurry have equal effects on horn swelling and hardness even though urea, ammonia and sulphide anions are known to uncouple hydrogen bonds and disulphide bridges in keratin, causing this molecule to unfold and to swell as fluid invades[4,9]. Since the claw horn is naturally exposed to the above environmental elements it may have an innate resistance to them. Formaldehyde pre-treatment of claws 15 minutes prior to exposure to fluids decreases the horn softening effect by over 70 %[7].

Desiccation of the claw horn occurs but takes 3 to 4 times as long as hydration at equivalent temperatures and humidity[5].

Cow groups visiting the milk parlour vary in size. Herds predominantly at pasture usually consist of larger groups, which will mean that the average turn-around time per cow unit on the wet concrete parlour floors will be close to 2 hours per milking session. Another 8 hours in dry pastures will be required to return the hooves to their original hydration status before returning to the abrasive concrete floors. Cows in free stalls , although visiting the parlour in smaller numbers with a shortened turn-around time on the wet concrete floors, generally return to damp concrete of the free stalls, as these areas are continually flushed down to prevent slurry build-up. These animals will have continually hydrated soft hooves.

A number of investigations have determined that sound cows on average had harder claws than did injured cows within herds, which supports the notion that softer claws are at greater risk for injury and subsequent lameness[5,11,12,22]. Rear claws have a higher moisture content and those with 'thin soles' even more so, which implies that the rear feet will be more prone to problems. In a commercial dairy, 30 % of the rear feet of 'thin sole' cows had pathological lesions, with 72 % having white line disease and 28 % sole ulcers. Seventy-seven per cent of claw lesions occurred in the lateral claw, which carries the most weight and therefore wears most rapidly and consequently is more commonly affected by 'thin soles'[20].

An association between rainfall and the incidence of claw lesions has also been identified[20].

HORN GROWTH RATE AND WEAR

Growth rates and wear depend on breed, genetics (heritability factor of 0.20 for rate of wear across breeds)[10], nutrition, environmental factors (including surface characteristics,seasonal changes, humidity, temperature, management factors, etc.), age, weight-bearing biomechanics and corium blood supply (affected by systemic disease and mechanical trauma)[10.16].

Claws grow continuously. The suspensory apparatus of the laminar corium has to maintain a very tight and secure bond with the claw capsule wall; however, it must also allow the wall to grow downwards relative to P_3 to accommodate the continual wear at the base of the wall horn. The intercellular bonds (small protein bridges) that bind the corium to the epidermal wall horn, especially in the basal and spinous cell layers, have to detach, realign and rebind to cater for this growth and movement but at the same time must maintain adequate bonding strength[13]. To achieve this, the wall movement must be gradual. It has been recorded that the dorsal wall growth rate for adult Friesian cows is expected be 5–6 mm/month[8,10.16]. An average value of 4 mm/month for the dorsal wall has been measured in Ayrshires, whereas the same in sheep varied from 3.8–6 mm/month[15]. Growth rate is affected by wear rate and will generally adapt in time to increased wear. Horn growth usually exceeds wear, which is most pronounced in young animals[10].

The soft perioplic heel horn grows about 40 % faster than the dorsal toe wall, whilst the lateral wall, only 22 % faster[10.15]. This is the reason for diverging 'hardship' grooves.

Sole growth rates are slower at 3– 4 mm/month because the sole should not outgrow the wall[8,16]. If it did, the sole would protrude beyond the distal claw wall and would then carry most of the weight of the limb.

Hind claw growth and wear rate can be up to7 % faster than front claws; however, with competition for bunk space on concrete floors the slipping of the front feet may reduce or even reverse this figure significantly[10]. Calf claw growth rates of 26 % to 28 % faster than adult rates on similar diets and surfaces have been recorded. An increase of 2.5 times normal rate in young feeder cattle on high planes of nutrition is also mentioned[10.15,16].

Confined animals on concrete had faster growth rates (>15 %) and an even faster wear rate (>30 % or 0.71 mm/month more than growth) than pastured cattle[10]. This increased wear rate preceded the increased growth rate and, although adaptation does occur, it is delayed by up to 4 –6 weeks[6,10]. However, these confined cows with their continuously thinning weight-bearing claw surfaces were placed in pastures during the dry period and the claw thickness recovered[10]. Fresh abrasive concrete increased horn wear rate by >35 % when compared to cattle on pasture[10]. The importance of leaving hooves slightly longer than normal during trimming in the late dry and early lactation periods is therefore self evident. Cows standing on rough concrete during their lactation cycle need a dry period at pasture to recover horn lost whilst on the concrete[10].

'Thin soles', defined as short dorsal wall length and palpably soft soles, is a recognised problem in some lactating herds on grooved concrete. An incidence of up to 30 % of cows has been recorded, which makes it the single biggest hoof problem in these herds[19]. As the sole becomes thinner, less protection is afforded to the deeper structures and it is therefore not surprising that many disorders that contribute to dairy cow lameness involve the sole[9]. Second lactation cows are more affected than 1st or 3rd lactation cows. The reason suggested for this is that there may be a carry over from excessive wear in the 1st lactation with insufficient sole re-growth during the dry period. Cows entering their 1st lactation have a normal weight-bearing horn thickness and are still growing into their claws, with a relatively faster horn growth rate compared to more mature cows, and therefore the consequences of a lactation on concrete will only surface in the 2nd lactation. Mid- to late-lactating cows had an incidence of 'thin soles' double that of other stages and the reason given was that the abrasive walking surface possibly resulted in a faster rate of sole horn wear[19]. This should apply to all cows visiting the parlour, but

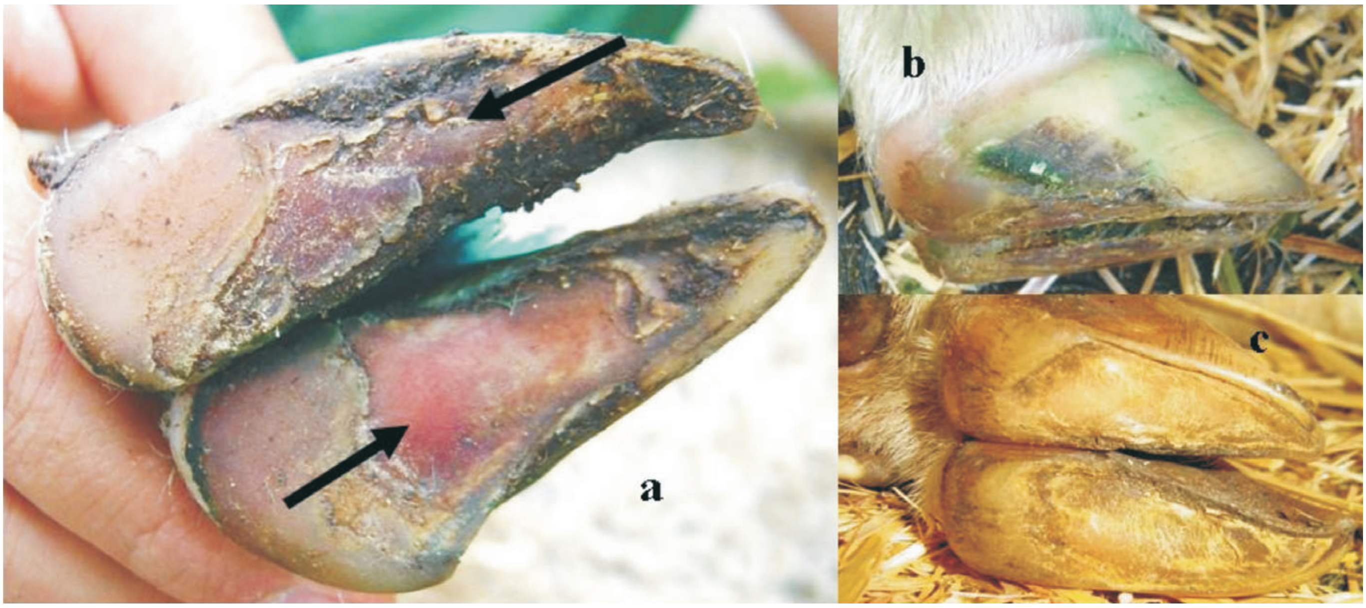

Fig. 2: a, **Flattened weight-bearing surface of the claws of a Merino ewe with severe sole haemorrhage** (arrows); b, **lateral view illustrating worn down wall horn and flat weight-bearing surface;** c, **normal sheep claws with slightly protruding wall horn and concave, sloping soles.**

fresh cows will have to wear down the sole re-growth that occurred during the dry period before exhibiting signs of 'thin soles'. The higher incidence in all groups during summer is associated with a higher claw horn moisture content resulting in softer horn that wears more rapidly[19].

Case 2

A large, well-managed dairy concern decided to change from a pasture-based system to a free stall system. New, relatively inexperienced hoof trimmers were requested to attend to all claws, regardless of lactation stage, during this transition. The fee was based on the number of legs done and because of inexperience even normal claws were 'touched up' as proof that these claws were checked. The 'touching up' mostly involved lowering the protruding lip of the distal wall horn and by skimming off a thin layer of the solar and heel surface. This was potentially disastrous since the main weight-bearing surfaces are lowered, resulting in more pressure transferred to the sole which had also been thinned, resulting in softer underlying horn being exposed. The change from pasture to freshly laid, wet concrete in the stalls would result in softer claw horn and faster wear. The increase in growth rate would be delayed and would be insufficient to replace enough of the lost horn for adequate claw protection. Thin ventral hoof surfaces resulted in many animals becoming lame and within a month or 2 various related complications occurred. Besides a sudden drop in milk production, a number of cows developed toe ulcers that invariably undermined large areas of the sole[17]. A number of these cases presented with osteolysis of P3, with some exhibiting pathological fractures of the pedal bone. The major predisposing factor is believed to have been over-trimming of the claws that left thin soles and an inadequate wall length. Untimely and inappropriate over-trimming can result in severe economic loss to the farmer.

Seasonal effects generally produce faster growth and wear rates in the warmer periods, probably because of the higher claw moisture content from the increased rains. Also, with exposure to low environmental temperatures, peripheral vasoconstriction will restrict blood supply and decrease horn growth[10].

Other factors that may affect growth include disease, which affects nutritional intake and consequently its influence on horn growth. Problems involving perfusion, like dehydration and/or anaemia, will cause redistribution of the vascular supply to the vital organs. Sluggish and poor blood supply to the hooves will leave the distal tips of the laminae of the laminar corium and the ends of the conical projections of the other 3 coria in a relatively greater state of anoxia owing to the counter-current effect. Nutrient and oxygen supply to the basal cells will be compromised, which will negatively affect horn growth rate and quality.

Case 3

A merino ewe was admitted to the clinic owing to severe lameness. She preferred to crawl around on her knees and elbows but when forced to stand she displayed an arched back, was noticeably cramped and extremely reluctant to move. A clinical examination revealed that all the claws were worn flat on their ventral surfaces (Fig. 2) with signs of severe, extensive bruising. The soles were very soft and extremely sensitive to light palpation. Normal soles should have a concave shape sloping up towards the interdigital cleft. This area should be bordered by a protruding distal wall on the abaxial and toe area as well as a small section of the cranial axial wall. A prominent heel should complete the weight-bearing surface of the claw. Three weeks earlier the ewe had been treated for severe lameness that was diagnosed as a complication of bluetongue. This viral disease invariably causes severe stomatitis and coronitis, both of which will affect horn growth and quality, the 1st affecting nutrient supply and the 2nd affecting basal cell growth. Part of the initial treatment was to restrict exercise and the farmer removed the ewe from the pasture and isolated her in a small concrete camp that was hosed down daily. Firstly, she was not used to concrete and secondly, being a gregarious animal, she had paced excessively especially as the rest of the flock could be seen on an adjacent pasture. This resulted in excessive wear of the poorer quality, softer, non-adapted weight-bearing claw horn, resulting in the severe lameness as seen on presentation.

In humans, pregnancy increases nail growth rate by 25 to 33 % compared with the normal rate but this effect in production animals such as domestic ruminants will already be factored into the horn growth rates, as these animals should mostly be pregnant[1].

ENVIRONMENTAL FACTORS

Cows in straw paddocks have the lowest levels of claw disorders[7].

Cattle standing in wet environments have swelling and subsequent softening of the claw horn, which can increase wear rates. Structural degradation by environmental agents and abrasion can further increase this wear rate, which will expose the softer, less mature horn even more rapidy. Rate of wear will accelerate and the horn will be even more prone to the damaging effects of the ensuing environmental factors.

Uneven and or abrasive surfaces have long been implicated in increased wear rates of the weight-bearing claw surface[10]. Surface roughness assists cattle movement by improving frictional properties and reducing slipperiness. However, floors lacking friction, either by poor design or by the presence of slurry/moisture, have been shown to influence cow limb excursions and lead to increased slipping and or injury[4]. More abrasive floors can lead to excessive wear so a compromise between the 2 is a matter of ongoing research. Frictional interaction between claws and floors depend on claw size, shape, horn properties, flooring properties, external environmental influences and locomotory characteristics (*e.g*. contact angle, speed, etc.)[7]. Frictional coefficients (ratio of the force required to move 2 bodies relative to each other (*e.g.* a claw sliding over a surface)) to the force pressing the bodies together (*e.g.* the weight of a limb exerting pressure on the same surface) are measures determining this frictional interaction. A frictional coefficient close to zero implies excessive slipperiness, meaning that very little force is required to move 1 body over the other, like steel on wet glass[4]. A covering layer of short lengths of dry straw on smooth concrete will have a low frictional coefficient, whereas within a thick pile of the same dry straw the frictional coefficient between each individual piece will be even lower, making this medium even more slippery. Rubber on an abrasive tar-macadam surface can reach a frictional coefficient value of up to 1.6, which implies that more force than the weight carried by the rubber is required to move the rubber over that surface (*i.e.* exceptional 'grip' as in formula 1 racing cars)[4].

Surface roughness and specimen hydration interact to alter frictional coefficients and to alter mechanical work required to lose a unit volume of hoof by abrasive wear[4]. Of the 2, surface roughness is the main factor mediating friction, with frictional coefficients increasing by as much as 23 % (less slippery) between smooth and rough surfaces[4]. Horn hydration differences will only have a maximal 3 % effect[4]. Frictional coefficients are also split into static coefficient of friction (μ_s) (from a standstill or from rest) and dynamic coefficient of friction (μ_d) (while moving)[7]. The static coefficient of friction is usually larger than the dynamic coefficient of friction, as momentum in the latter decreases the force required to overcome the resistance between the 2 bodies. With softer flooring surfaces these values converge as the claw will penetrate further into the softer flooring material and hence increase its dynamic coefficient value. Dynamic friction more accurately reflects the risk of slip at the start of the supporting limb phase (heel strike in the step cycle), when the claw is gaining contact with the floor. Static friction may more accurately represent the risk of slip before lifting the limb (push off in the step cycle) since the claw is static at this time. One study determined the frictional coefficient of dry and wet claws on a rough abrasive surface to be 0.86 and 0.88 respectively, whilst on a smooth abrasive surface they were 0.70 and 0.75 respectively[4]. This study did not differentiate between μ_s and μ_d so the values are probably a combination of the 2. Another study gave values of $\mu_s = 0.8$ and $\mu_d = 0.69$ for heavily sandblasted concrete and other results stated $\mu_s = 0.51$ and $\mu_d = 0.43$, probably with less rough concrete flooring[7]. Damp concrete always results in μ values greater than those obtained on dry concrete, which implies that dry concrete is more slippery than damp concrete. As the coefficients of friction increases, the resistance to slip increases and so step length increases and the number of steps decreases to maintain speed. As friction increases the claw does not need to be in contact with the surface as long to maintain a stable platform so the hanging limb phase will increase at the expense of the supporting limb phase. On a more slippery surface cows walk more slowly with considerably shortened strides and with rear feet placed a greater distance behind the front ones, which results in more weight being transferred to the bulb area of the front claws, with increased wear in these areas. The frictional coefficients of the front claws are significantly higher than those of the rear claws, possibly because the front claws are usually larger[7]. This also implies that the rear claws will slip more on the same surfaces and therefore suffer more wear.

Work done to remove a fixed amount of wall horn was 76 % less with a hydrated sample (horn immersed in water until a constant mass is achieved) than a dry sample (horn dried in an oven at 105°C until a constant mass is achieved) on the same rough abrasive (40 grit, 412 μm particle size) surface[4]. The dry sample 'slipped' more easily over the abrasive surface. However, 112 % more work was required to wear down equivalent amounts of horn on a wet sample compared to the dry sample on a very smooth (220 grit, 65μm particle size) surface. The moisture in the hoof was acting as a lubricant and a coolant. In milking parlours and gangways rough surfaces are the norm as grip is essential. On rough abrasive surfaces dry hooves are preferred, whereas on very smooth surfaces hydrated hooves are better.

Hoof trimming methods will alter hoof-floor frictional coefficients mainly through changing the weight-bearing surface areas and shape of the hooves.

When cattle are housed or penned on freshly made concrete floors, lameness appears more evident than on 'cured' concrete and it was assumed to be due to severe sole abrasion by the rough, uneven concrete surface. This condition was termed 'New Concrete Disease'[10]. New fresh concrete forms a thin suspension of calcium hydroxide on its surface which has a very high pH of over 12[9]. At this pH, keratin is very susceptible to degradation and claw horn can become severely compromised. Washings from 3-day and 7-day-old concrete floors induced horn swelling of >50 % and >33 % respectively over and higher than that of rainwater alone[9]. Normally calcium hydroxide at the surface of newly laid concrete is carbonated by atmospheric carbon dioxide but this can take a number of weeks to months. Washing new concrete with fresh water to eliminate this surface alkali will dilute the immediate product, but since this is continually being formed, continuous washing is required. Curing of the concrete will be substantially extended with continued washing, which will prolong the problem. The physical effect of the washing process may even pit the uncured concrete, causing it to become more abrasive and uneven.

Case 4

A game farmer erected new pens with fresh concrete floors all under roofing. He purchased a number of captive buffalo from an established buffalo breeding project. A few weeks later a trophy buffalo bull became severely lame and a visit to this concern was requested. All the animals needed to be anaesthetised to collect blood for disease surveillance and the opportunity was used to check their hooves, as a number of them appeared to be walking around rather gingerly. Without exception, all the ventral surfaces of the hooves examined were worn flat with claw horn can be immediate, growth needs time to adapt to new environmental conditions. This can result in excessive thinning of the weight-bearing claw surfaces. Animals standing on rough concrete throughout their lactation period need to spend the dry period at pasture to recoup lost horn. Newly laid or fresh concrete is very corrosive and cows placed on these surfaces must be continually monitored for pathological thinning of the weight-bearing hoof surfaces. Trimming is an immediate, purposeful thinning of the weight-bearing surface which is necessary in overgrown claws. However, in the late dry period and early lactation this trimming, if necessary, must be more conservative than normal to accommodate the increased wear rate that will occur during the cows' stay on concrete. Overzealous hoof trimming must be prevented.

Fig. 3: **The buffalo bull charging around on his elbows and knees. The freshly laid, grooved concrete surface is visible as are the cows in the adjacent pens.**

Fig. 4: **The severely worn weight-bearing claw surfaces of the buffalo bull illustrating the paper-thin soles and exposed solar corium.**

rough, raspy soft horn visible and the soles were palpably soft. The fresh, damp concrete without exposure to the sun had not cured sufficiently and was more abrasive than the floors the animals had previously been used to. The buffalo were also unsettled with the relocation and were uneasy and more fidgety trying to re-establish pecking order and to find places to eat, sleep and drink, and therefore moved around more than before. Both these factors would have caused the excessive wear that was noted. The lame bull was in sternal recumbency and unable to rise, and despite this he still charged at us on his knees and elbows owing to his aggressive temperament (Fig. 3). He was anaesthetized and all 8 claws had paper-thin soles that could be peeled away, exposing solar corium that was badly damaged over large areas (Fig. 4). This bull was far worse than the others, probably because he paced incessantly owing to his aggressive nature and also because he was isolated by a few poles from the cows in adjacent pens. It was later learned that because of his aggressive nature the previous owner had placed this bull in a separate dirt camp next to the concrete pens. This animal had not been adapted to concrete and with his continued pacing on the fresh, damp concrete had worn his weight-bearing claw horn surfaces almost completely through.

CONCLUSION

Although it is common practice in cattle, especially dairy cows, to trim the abaxial wall flat with the sole it is the opinion of the author that the wall should project below the level of the sole, since the wall is the main weight-bearing component of the claw and as such it should protect the sole from being excessively burdened and will prevent the sole from wearing excessively especially when walking over abrasive surfaces under high moisture conditions. Whereas wear and tear of

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