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## ***'Lameness in cattle: Recent research to inform clinical practice'***

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### **Introduction**

Cattle lameness research has lagged behind that in similar fields such as fertility and mastitis. In part this is because relatively few drug sales are associated with its control and so it does not attract research funding from pharmaceutical companies interested in supporting medicine sales (c.f. mastitis tubes and reproductive cycle manipulation). Secondly there is now a weight of evidence which demonstrates that in part, lameness is a disease of high production: high yielding cows are more likely to become lame. As average milk yields in the UK and around the world have increased, lameness has become more important both in terms of the absolute numbers of cases seen and its relative importance as a key endemic disease. The chronic under investment in lameness research has resulted in large gaps in our understanding of aetiopathogenesis, treatment and prevention. Much of what we think we know about lameness control is in fact received wisdom, unsubstantiated by experimental work.

It is not the intention of this article to review all scientific evidence on lameness in cattle, rather it aims to provide an update on research based advances in the field published from around the world over the last 5 years. These developments have improved our understanding of lameness in cattle and can inform clinical practice and the control of lameness on-farm.

This is the first of a series of two articles. In the second article Sophie Mahendran and others will cover the understanding and management of claw health and claw horn lesions.

### ***What is a Lamé Cow?***

While most practitioners will feel that they can identify a lame cow when presented with one, it is important to have a consistent definition of what we mean by a "lame cow" on-farm (This can be compounded by a disconnect in what the practitioner terms a lame cow and what the farmer terms a lame cow. This will be discussed later in '***Understanding Farmer Attitudes and Perceptions***'). Accurate definitions are particularly important when assessing herd level data and when benchmarking farms. The clinician can be presented with a range of lameness data:

- Herd mobility score data (Figure 1)
- Records of lesions identified during routine trimming (usually without associated mobility scores)
- Treatment incidence records

Research has demonstrated a number of complications associated with these data. In the case of treatment incidence records, most farmers only tend to treat severely lame (Score 3) cows and that many weeks can elapse between when animals are first identified as lame by external observers and when they are treated. Even then recording of these treatments is often patchy at best (especially if no medicines are administered). Therefore these records may only include the most chronically and severely lame animals. They should be regarded with scepticism unless careful quality control is instituted on-farm.

Typically, lameness is detected by visual observation of abnormal locomotion. Assessment of gait provides a subjective assessment of impaired locomotion which for chronic and severe lesions, such as sole ulcers, has been shown to correctly classify presence or absence of lesions in over 90% of animals. However, for earlier and milder claw horn disease (see Early and Effective Treatment) such as sole haemorrhage, and digital dermatitis, this method has been shown to be unrelated to the presence or absence of lesions. In the case of claw horn lesions this may be because the discomfort

is associated with injury to and bleeding from the corium. This damage may not become visible for weeks until it grows out with the sole horn. This raises interesting questions such as 'How should we treat lame cows identified by mobility score which don't have lesions?' and 'Should obvious lesions identified during routine trimming be treated if the animal isn't lame?'. Should either or both of these cows be recorded as lame in incidence records; i.e. should impaired mobility or the presence of lesions be used to define a lame cow?

To answer these questions the significance of impaired mobility and lesions on lifetime health, welfare and productivity become important; further research is required to understand this more fully. In the meantime, to build up a picture of lameness in a herd, the authors advocate both prevalence (mobility scoring) and incidence (treatment records) data, providing the clinician appreciates the limitation of both sources (Archer and others 2010).

### ***Advances in our Understanding of Digital Dermatitis***

Despite what can often be assumed, the aetiology and pathogenesis of digital dermatitis remains relatively poorly understood. Whilst many bacteria can be isolated from digital dermatitis lesions most of the recent research implicates the involvement of the Treponeme genera of spirochaetal bacteria. Researchers at Liverpool Veterinary School have identified three phylogroups that appear to be consistently present in digital dermatitis lesions. These three groups are known as "*Treponema medium/Treponema vincentii*-like", "*Treponema phagedensis*-like" and "*Treponema denticola/Treponema putidum*-like" with the third group now identified as the previously undescribed species *Treponema pedis*. It is not known how the organisms cause disease although they appear capable of migrating deep into the skin of the hoof possibly via the hair follicles. Ongoing research on the pathogens, pathogenesis and host-immune response continues, including work on developing an effective vaccine.

The disease syndrome is becoming increasingly recognised across a range of ungulates. Although historically considered a disease of dairy cattle, the condition has

now been definitively described in beef cattle and may become more important in these systems. These same Treponemes have also been identified in contagious ovine digital dermatitis, contagious caprine digital dermatitis as well as in skin lesions on pigs and recently in foot lesions on wild elk in North America. The apparent increase in the species range affected poses concerns about the potential for the development of wildlife reservoirs.

Traditionally digital dermatitis was thought to be associated with exposure to slurry, until recently attempts to identify the organism in fresh faeces and slurry had been unsuccessful. A recent report from Denmark has indicated that genetic material from the Treponemes described above can be identified from these sources. Perhaps of more importance, recent work has identified the organisms on hoof knives and other hoof trimming equipment both before and after disinfection. This may potentially be an important source of transmission, although it is not currently known how long the organisms can survive on the equipment. At present, the only definitively identified source of these organisms remains the lesions of infected animals. Movement of infected animals is likely to be the most important route of transmission between farms although the hoof trimming equipment work highlights the possibility of fomite spread and hence the importance of careful biosecurity measures for those of us working across many different units.

The 'M Scale' first described by Döpfer has become the most widely used digital dermatitis lesion classification system (Figure 2). Epidemiological modelling has indicated that the M2 and M4 lesions are most important in the spread and persistence of digital dermatitis in a herd; the relationships between the stages are illustrated in Figure 3. Disease can be effectively controlled by efficient, prompt, topical treatment of acute (M2) lesions and by using routine disinfectant footbathing to minimise the number of chronic (M4) lesions relapsing to acute (M2) lesions. Clinical experience suggests that, whilst digital dermatitis cannot be eliminated once it is present on a unit, prompt treatment of acutely affected animals and regular, routine footbathing of all cows in the herd can afford high levels of control. As our understanding of digital dermatitis

improves, new, more targeted treatments and prevention strategies may become available.

### ***Footbath Design and Footbath Solutions***

All the evidence suggests that digital dermatitis can be successfully controlled on-farm if all animals (including dry cows and ideally heifers in late pregnancy) are regularly and routinely footbathed through an efficacious solution. Whilst many solutions are available, 2-5% solutions of formalin or copper sulphate have proved the most successful in experimental research and remain the most widely used on-farm. One cow passage per litre of solution (e.g. a max of 250 cow passes through a 250L bath) are commonly quoted but not based on any tangible evidence. Both solutions are problematic. Formalin is both carcinogenic and toxic and therefore needs to be used and handled with care. Copper sulphate can become toxic on pasture if slurry containing the solution is spread on land over prolonged periods (particularly if it is co-grazed by sheep). Whilst many other solutions have been suggested, and increasingly proprietary footbathing agents are becoming available, most have either not been tested or proved less efficacious in research studies and/or are more expensive than formalin or copper sulphate. Further work is needed to identify effective, yet safe, alternatives. A recent UK Vet article (Bell and others 2014) has provided a systematic review of the literature surrounding footbath solutions; the reader is referred to this article for further information.

For effective on-farm control, regular and routine means between 2 and 7 days per week, every week. Frequency can be adjusted depending on the presence or absence of active lesions. It is vital that footbathing systems are carefully designed and purpose built so they are quick and easy to use. Current best practice is to ensure cows' feet are clean before running through the footbath, although recent research has questioned the necessity and efficacy of pre-baths. Evidence suggests that footbaths should be long enough so the cow must place each foot in the bath at least twice and deep enough for the solution to cover over the top of the coronary band. The minimum

length for 95% of cows to place all feet down twice is 3m. Cows seem to prefer to step over a barrier into a footbath rather than down into a sunken bath. This type of bath is likely to be easier to empty and clean out as well and so is preferable if farmers are considering installing a footbath. Footbath design is a complex area. Most recommendations are based on practical experience rather than research evidence, and the reader is referred to guidelines from organisations such as DairyCo for further information in the area.

### ***Non-Healing Lesions***

Non-healing claw lesions of different types are increasingly being reported from around the world. Numerous types of non-healing lesions are described from non-healing varieties of 'classic' lesions such as sole ulcers or white line disease (Figure 4) to newer 'emerging' lesions such as toe necrosis (Figure 5). The pathogens commonly detected in digital dermatitis lesions have been found in all types of non-healing lesion. These lesions can often be difficult and unrewarding to treat; affected animals often require aggressive antibacterial (topical and parenteral) and surgical treatments or digit amputation (for many clinicians toe necrosis is now the most common reason for this procedure). There is currently a lack of peer-reviewed research on these lesions. Debate occurs over whether they are truly increasing in incidence or whether they are just being more widely reported. Either way these lesions seem to fall at the intersection of the classic distinction between claw horn and infectious foot lesions in cattle, appearing to be a result of secondary infections with digital dermatitis pathogens. It seems logical then, that control should focus on reducing the risk factors for claw horn lesions and implementing routine preventative strategies to control digital dermatitis. Further research is needed to elucidate the aetiological mechanisms involved in these lesions and to ascertain the most appropriate therapeutic and preventative regimens.

### **If Lame Cows could Talk: Behavioural Changes due to Lameness**

There is a growing range of research work which has described the impacts that lameness has on a range of cow activities. These changes are likely caused by the discomfort associated with disease. Lameness causes dairy cows to modify their behaviour and directly impacts on how they apportion their time. One of the first signs is an increase in lying time through an increase in the duration of each lying bout. Simultaneously, lame cows progressively reduce their feeding intake; feeding time decreases as mobility score increases. When lameness is acute an overall reduction of feeding time is compensated with an increase in feeding rate during feeding bouts. Lameness also negatively impacts on the expression of oestrus. Lame cows are less likely to both mount other cows and be mounted themselves; meaning oestrus is less likely to be observed in these animals. Finally, lame cows in conventional parlours tend to be last in the queue and those housed in automatic milking systems decrease their voluntary visits to the milking robots. These behavioural changes are more dramatic in younger animals and those with claw horn lesions.

Behavioural changes associated with lameness can have profound affects both on the effective and efficient running of commercial units and on the incidence of other production diseases. Whilst some of these associations have been extensively explored (e.g. the negative impacts lameness has on reproductive performance) it is very likely that we do not currently understand their full implication, for example we do not understand the impact an increase in feeding rate has on rumen function. Whilst understanding and quantifying these behavioural impacts is important, ultimately the key is to prevent lameness from occurring and treating cases which do occur promptly and effectively to limit the duration over which animals are lame.

### ***Understanding Farmer Attitudes and Perceptions***

Recently, a range of research has been conducted exploring farmer attitudes towards lameness and lameness control. This work can be hugely informative as it identifies the motivators which can be used to inspire change and the barriers which must be overcome when attempting to implement control programmes on-farm.



Studies on farmers' attitudes to lameness have revealed that the large majority of them did not perceive the economic losses caused by lameness even when lameness prevalence was high (36%). Well over 90% of farmers considered that the pain and suffering of the cow was a very or extremely important consequence of lameness and 'Pride in a healthy herd' and 'Feeling sorry for lame cows' were reasons given by farmers for controlling lameness. The time and labour needed to control and treat lameness were considered as important limiting factors. This work suggests that on most farms it may be better to focus discussion more around the perceptions of and concerns around health and welfare rather than attempting to motivate change through potential financial return.

Importantly, any communication with farmers about lameness must take into account farmer views of what constitutes a lame cow. In a recent study the authors concluded that 'What is striking is how farmers avoided using the word *lame*' (Horseman and other 2014, Figure 6). The work suggests that for most farmers, 'lame' is a term reserved for severely lame cows (Score 3); cows with mild lameness / impaired mobility (Score 2) are not considered lame and were not a priority for treatment. It also suggests that previous work which has demonstrated that farmers under-estimate their lameness prevalence, may be incorrect. Instead, farmer's may be correctly categorising Score 2 and Score 3 cows but only labelling Score 3 cows as 'lame', i.e. they are correctly reporting the number of animals they consider 'lame'. Recent work suggests that it is important to target Score 2 cows (see Early and Effective Treatment), understanding farmer terminology and finding way to effectively discuss these cows with farmers are vital.

When talking about lameness treatment it is important to consider farm facilities and staff training, as a lack of hoof trimming skills and poor quality foot trimming facilities were considered the main barriers to providing prompt treatment. Of note is the fact that many farmers do not differentiate between sole ulcer / haemorrhage and white line disease; they are considered one and the same as far as on-farm treatments are concerned. The implications of these findings are considered in more depth in the section on Early and Effective Treatment and in Figure 8.

### **Early and Effective Treatment**

The term 'Early Effective' first coined by researchers at Bristol Veterinary School encapsulates current thinking on lameness treatment and the message that should be conveyed to the industry. A number of separate studies have provided research evidence supporting this approach:

- Delayed treatment is a risk factor for higher levels of lameness within a herd
- Animals which are lame in their first lactation are more likely to go lame in subsequent lactations
- A history of lameness is a risk factor for being identified lame again in the future
- Early treatment leads to more rapid recovery and less repeat treatments
- The longer animals stay lame, the less likely they are to recover
- The large majority of cows progress through Score 2 before becoming Score 3 over a number of weeks; i.e. few cows suddenly become severely lame

When considered in black and white, the 'Early and Effective' message may seem like a statement of the obvious. However on-farm research has demonstrated that there are often long delays (many weeks to months in some cases) between when cows can first be identified as lame (Score 2 or 3) by an external mobility scorer and when they are treated on farm. Yet, when questioned, the majority of farmers say they treat lame cows within 48 hours of them becoming lame. How do we square these seemingly contradictory findings? Social research demonstrates the delay may in part be due to terminology and differing perceptions (See 'Understanding Farmer Attitudes and Perceptions' and *Figure 6*). Many farmers do not consider Score 2 cows 'lame', consequently if they are not considered 'lame' they may not be considered for treatment.

So whilst the early and effective message may seem obvious and straightforward, it actually hides a huge amount of complexity to deliver this approach on farm. In order to succeed treatments need to be administered early, as soon as animals become mildly lame (Score 2), using effective treatment protocols and delivered by skilled operators.

The most successful farms have instituted regular and routine mobility scoring followed by immediate examination and treatment of lame (Score 2 and 3) cows (Figure 7). Significant barriers to this approach and suggested solutions are outlined in Figure 8.

Increasingly the authors are drawing an analogy between lameness and mastitis, a disease in which early and effective treatment is considered the norm and farmers are very familiar. No farmer would leave a few clots at milking for weeks, letting the mastitis progress to become a severe and chronic case before they instituted treatment, yet this is currently the situation for many cases of lameness. Extending the analogy, we believe chronic Score 3 cows should be thought of in the same way as the chronic high cell count cow and should be considered for culling. They are in pain and discomfort and it is unlikely that treatment will lead to anything other than a temporary resolution of clinical signs. This allows the focus of treatment attention to shift to Score 2 cows, preventing them becoming more severely and chronically lame.

### ***New Technologies***

Increasingly, new mobile and on-line technologies are transforming the way we monitor and control lameness. Ruggedised laptops facilitate the amalgamation of mobility and lesion data at cow-side, with automated alerts informing targeted management of cases and allowing data sharing between vet, farmer and foot trimmer. Modern high-tech, hydraulic portable crushes enable rapid and efficient trimming and treatment. These resources, combined with the paraprofessional services offered by veterinary practices and other contractors are becoming adopted in lameness management for their ease and reliability. The rate of progress and the tools available are only likely to increase in the future.

Automated systems for lameness detection and monitoring would significantly assist the day to day monitoring and treatment of lameness. They are slowly becoming commercially available following developmental research. Options include force plates analysing gait length and weight distribution across limbs, automated video analysis of walking speed and gait and combinations of accelerometers and real time positioning

technologies for monitoring behaviour. Challenges which remain to be addressed include issues around sensitivity and specificity, robustness (to cope with the hostile conditions on-farm) and cost. Automated systems could revolutionise lameness detection and monitoring in a similar way to the recent automations seen in oestrus detection. While none of the available systems presently address all of these challenges, with further development we could see them becoming more widely adopted throughout the industry.

The problems associated with lame cows without apparent lesions were discussed above ('What is a Lame Cow'). Handheld infrared thermometers are now widely available and may provide a solution. Research has demonstrated that they can identify the raised skin temperature caused by increased blood flow and inflammation in both infectious and claw horn lesions. Since foot temperature varies between animals, environmental conditions and stage of lactation, looking for differences between the temperature of the front and hind feet of the same cow appears to make the tool most useful.

### ***Conclusions***

Lameness in cattle has significant consequences for welfare, health and productivity. Whilst our understanding of lameness has historically lagged behind similarly important diseases, large amounts of research work is currently being conducted in the UK and around the world. It is vital these findings are implemented on-farm to minimise the impacts of this painful condition.

### ***Acknowledgements***

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DairyCo have a wealth of high quality, UK specific lameness resources available on their website and YouTube channel

The Cattle Lameness Conference, an annual UK focused event covers latest research and on-farm lameness control. Proceedings are freely available for download a few months after the event each year (<http://www.cattlelamenessconference.org.uk/CLCLinkPage.html>).

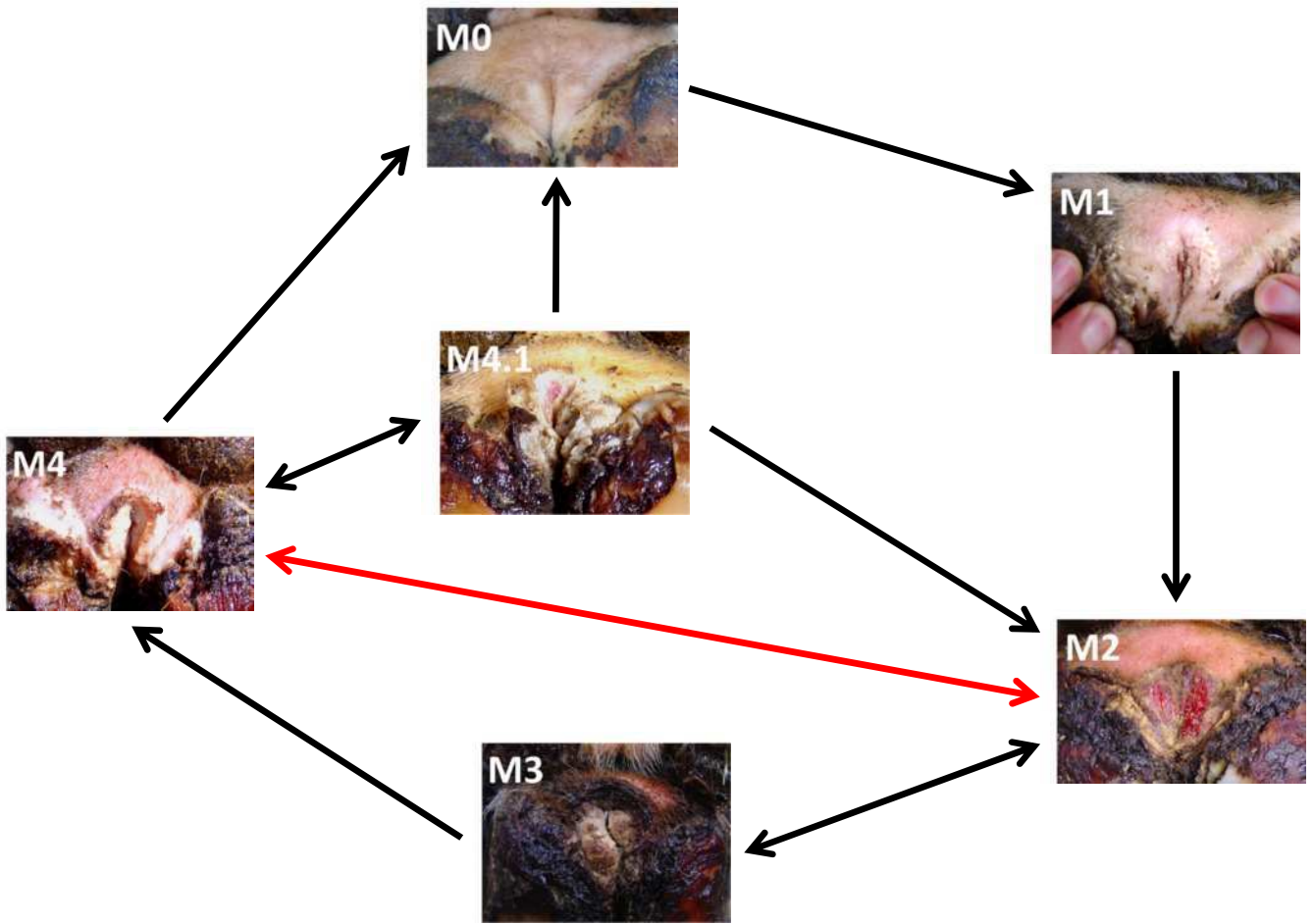
**Figure 1: The UK standard scoring system for lameness identification**

As per Table 1 in Archer et al (2010), In Practice, 32: 492-504

	<p><b>M0 Lesion</b></p> <p>Normal digital skin without any signs of DD</p>
	<p><b>M1 Lesion</b></p> <p>Early, small circumscribed red to grey epithelial defect of &lt;2cm diameter that precedes the acute M2 stage</p>
	<p><b>M2 Lesion</b></p> <p>Acute, active ulcerative (bright red) or granulomatous (red-grey) digital skin alteration &gt;2cm diameter</p>

	<p><b>M3 Lesion</b></p> <p>Healing stage within 1 or 2 days of topical treatment, the acute lesion is covered with a firm scab like material</p>
	<p><b>M4 Lesion</b></p> <p>Late chronic lesions that may be dyskeratotic (mostly thickened epithelium) or proliferative or both. The proliferation may be filamentous, scab-like or mass proliferations</p>
	<p><b>M4.1 Lesion</b></p> <p>Chronic lesion with subacute component(s)</p>

**Figure 2 The 'M Scale' of digital dermatitis lesion classification (After Döpfer and other)**



**Figure 3: The relationship between digital dermatitis 'M' lesions (after Döpfer and others)**

The red arrow indicates the key target steps of control plans in preventing relapse of chronic lesions to the infectious M2 lesion by footbathing and prevention of M2 lesions forming the chronic M4 lesion by prompt and effective treatment.





**Figure 4 Examples of non-healing foot lesions**

Arrows indicate the lesion.

Left: Extensive M2 digital dermatitis type lesion on a large area of sole dermis under a sub-sole abscess cavity (from an initial white line disease lesion). NB note there is also a more typical M4 digital dermatitis lesion

Right: M2 digital dermatitis type lesions on the sole dermis forming under a sub-sole abscess cavity (from an initial white line disease lesion).



### **Figure 5 Toe necrosis lesions and aetiology**

Images from left:

An early case of toe necrosis in a dairy cow; after extensive removal of horn from the toe, an M2 type digital dermatitis lesions can be seen on the exposed corium (arrow).

A sagittal section of a digit showing an early case of toe necrosis, lesions often extend to cause osteomyelitis of the distal phalanx.

An M2 type lesion at the coronary band of the dorsal wall (Picture courtesy of NJ Bell).

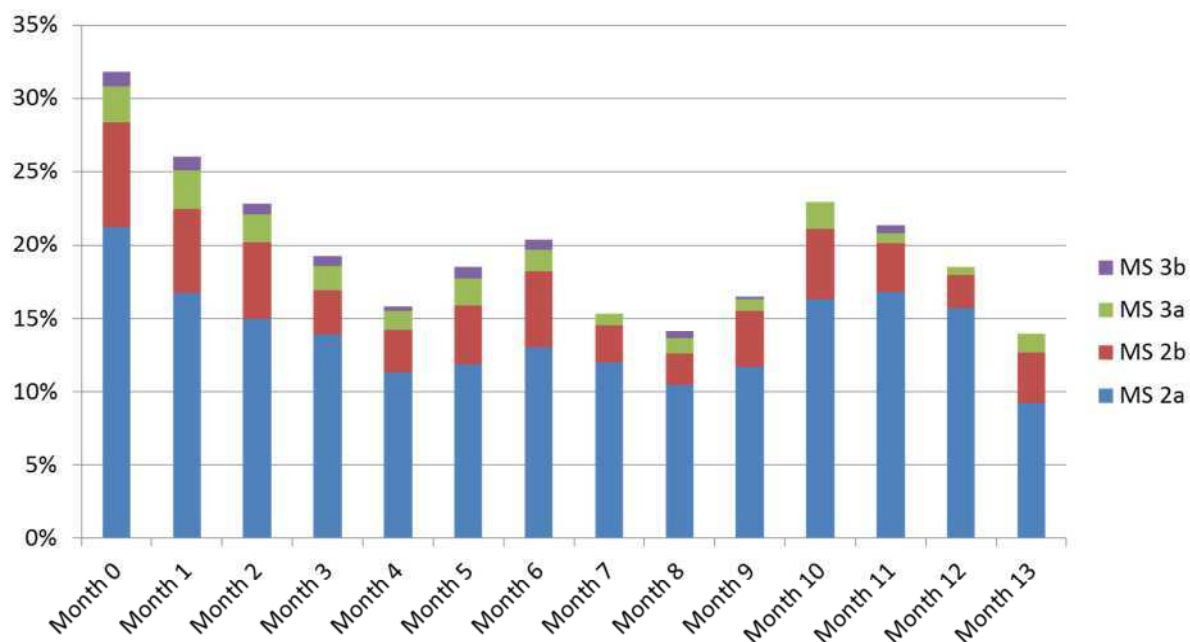
These lesions are difficult to treat and have been postulated to be the origin of 'necrotic toe' lesions.

Current proposed aetiologies for toe necrosis include: secondary, ascending digital dermatitis infection from a toe ulcer; migration of digital dermatitis infection through the hoof lamellae from lesions at the coronary band; secondary infection of axial wall fissures allowing entry of digital dermatitis bacteria.



**Figure 6: What is striking is how farmers avoid using the word lame** (Horseman and others 2014)

During a detailed interview on lameness treatment, dairy farmers used a variety of terminology to describe cows which would be considered lame (Score 2) by researchers and vets.



**Figure 7: Early and effective treatment (Thomas et al 2014, submitted)**

As part of a 14 month research study, approximately 1200 animals on five commercial farms were mobility scored every two weeks and treated as soon as they were identifiably lame ( $\geq$ score 2a following two non-lame scores. For research purposes DairyCo Mobility Scores 2 and 3 were subdivided into 2a, 2b, 3a and 3b). By the end of the study the proportion of lame animals in the whole population had dropped from over 30% to under 15% and there were no score 3b cows (the most severely lame category)

## **Figure 8: Barriers and solutions to early and effective treatment**

**Barrier:** Many producers do not consider that Score 2 cows are lame or in need of immediate attention, so they are not prioritised for treatment

**Solutions\*:**

1. Challenge the 'received wisdom', provide evidence demonstrating why these animals need to be identified early and treated immediately
2. Avoid dispute over terminology, call these animals 'Score 2' or 'Impaired mobility' (Remember many farms will not consider these animals 'lame')

**Barrier:** Many farms are resistant to routine mobility scoring. Attitudinal research suggests they consider it a waste of time and / or they are insulted as they believe that they observe and identify lame cows as part of their day to day routine stock management.

**Solutions\*:**

1. Discuss the advantages of a formal mobility scoring programme, particularly the early identification and treatment of Score 2 cows
2. Discuss barriers to mobility scoring with farm staff, incorporate mobility scoring into routine health planning
3. Provide practice training courses on mobility scoring or highlight opportunities offered by external providers (e.g. [www.dairyco.org.uk](http://www.dairyco.org.uk), [www.farmskills.co.uk](http://www.farmskills.co.uk))
4. Offer paraprofessional mobility scoring to clients as a practice service
5. Objective automated detection systems will increasingly become available in the future

**Barrier:** Treating lame cows is seen as difficult and time consuming, particularly if the on farm facilities are poor and / or there are other more pressing demands on time

**Solutions\*:**

1. Motivate and support the upgrading of foot trimming facilities. Facilitate visits to units with excellent set ups, provide information on suppliers and suitable equipment
2. Identify a member of farm staff to undertake treatments and allocate them time for the work so they have 'ownership' of the role
3. Employ external foot trimming contractors. If used they should be fully qualified members of the National Association of Cattle Foot Trimmers (<http://www.nacft.co.uk/wp/findtrimmer/>)

**Barrier:** Many operators treating lame cows on farm learnt on the job and have received no formal training. Treatments administered may not be best practice.

**Solutions\*:**

1. Provide practice training courses on trimming and treatment or highlight opportunities offered by external providers (e.g. [www.farmskills.co.uk](http://www.farmskills.co.uk))
2. Devise and institute standard operating procedures for common lesions\*\*. Ensure problem cases are referred for veterinary attention
3. Employ external foot trimming contractors (see above)

**Barrier:** High levels of lameness on-farm can be overwhelming, both in terms of the labour input that may be required to address the problem and the animal welfare implications

**Solutions\*:**

1. Initiate regular discussions on mobility and lameness during routine health visits. Don't avoid the subject and indirectly encourage a "head-in-sand" approach
2. During discussion, be sensitive to the 'cruelty' connotations associated with lameness, offer constructive advice and support rather than criticism. Promote the concepts of pride in a health herd
3. Motivate and support the phased development of an early and effective treatment programme to avoid the often overwhelming first phase. Offer practical suggestions if

labour is limited, consider outsourcing mobility scoring and/or foot trimming, particularly in the early stages when work load is likely to be high

4. Identify, support and develop 'early adopter' farms, utilise them as demonstration units to validate what can be achieved

\*The DairyCo Health Feet Programme provides the frame work for facilitated problem solving which allows farmers and staff to identify their own solutions to the challenges of early and effective treatment. It also includes a skills check to identify deficits in knowledge and lameness expertise (<http://www.dairyco.org.uk/technical-services/healthy-feet-programme/>). In addition DairyCo offer on-farm training in and high quality resources to support mobility scoring.

\*\*Recent work has demonstrated that almost without exception, treatments advocated for claw horn lesions have not been substantiated experimentally. This does not mean to say that current treatments are wrong, rather that we do not know what the best treatments are. Recent work conducted by the authors suggests that the application of a foot block and a course of NSAIDs leads to the best outcome in early cases of claw horn lesions. Experimental work is urgently needed to establish the most efficacious protocols, until that time farmers should be advised on current best practice.