2011

CATTLE LAMENESS CONFERENCE

Organised by:

Royal Veterinary College
University of London

The Dairy Group

The University of Nottingham

Topics are:

- Nutrition impact on lameness
- Cow tracks and cow flow
- Cow behaviour
- Latest research at Nottingham
- DairyCo Healthy Feet programme

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Wednesday 13th April 2011

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GENERAL INFORMATION

TIMETABLE of EVENTS

08:45	**ARRIVE / REGISTRATION / COFFEE and POSTER DISPLAY**	
09:20	**CHAIRPERSON'S INTRODUCTION** **Nick Bell, Royal Veterinary College**	
09:30	The impact of nutrition on lameness – a Review	**David Logue** University of Glasgow
10.15	Questions and Discussion	
10:30	**COFFEE and POSTERS**	
	Session 2 Chairperson: Jon Huxley, University of Nottingham	
	INTRODUCTION TO SESSION 2	
11:00	Cow tracks and cow flow – how they apply to lameness	**Neil Chesterton** New Zealand
11.40	Questions and Discussion	
11:50	Technology and behaviour: Studies of lame cows	**Nicola Blackie** Writtle College
12:30	Questions and Discussion	
12:40	**LUNCH and POSTERS**	
	Session 3 Chairperson: Brian Pocknee, *The* Dairy Group	
13.55	**INTRODUCTION TO SESSION 3 and VOTING ON POSTERS**	
14:00	*Milk loss, sore hocks, feeding time and foot trimmers. Recent lameness research at Nottingham*	***Jon Huxley*** *University of Nottingham*
14.45	*Questions and Discussion*	
14.55	*Implementing the DairyCo Healthy Feet programme*	***Owen Atkinson*** *UK Farm Vets Ltd*
15.40	*Questions and Discussion*	
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CHAIRPERSON'S INTRODUCTION

A VIBRANT FUTURE FOR FOOT HEALTH THROUGH PROVEN PRODUCTS AND SERVICES

We are delighted to welcome you to the 3rd Cattle Lameness Conference, hosted at the University of Nottingham's School of Veterinary Medicine and Science. As always we are extremely grateful for the time and enthusiasm given to us by our speakers but also all those who have contributed posters; without your input we would not have a scientific conference. We are also indebted to our sponsors who make this annual event viable.

Activity directed at lameness has reached an unprecedented high in the UK. This may reflect the raised awareness of what has been a growing problem, but it must also reflect the sense that something can be done about it. Perhaps the main priority for the future of lameness control is not just about the encouragement of activity, but the uptake of proven products and services.

To most, the road from blue sky science to changes on-farm seems painfully slow, particularly when the exciting breakthroughs do not miraculously appear when needed. In reality, the important scientific breakthrough is the one that takes the proven concept and converts it to commercial success. This can occur through partnership between academia and commerce, or through in-house commercial research and development. For the well-being of the cow and the farmer it probably doesn't matter how this happens provided it's safe and proven.

The conversion of science to commercial application is examined by many organisations, including DairyCo. Ten weeks ago DairyCo committed to the development of a commercial lameness advisory service, named the Healthy Feet Programme. This programme is embryonic in its development but has been influenced heavily by work from Wisconsin, Holland, UK, and its older sibling from New Zealand, Healthy Hooves. Healthy Hooves is a prime example of an industry-led commercial initiative based on clinical expertise, published research and farmer need.

The foundations for current lameness understanding were laid down by many researchers such as Professor David Logue, who will be exploring the contentious topic of "nutrition & the environment". If the foundations had not been well prepared, then many of the strands of lameness research would not be maturing now.

Future innovations are likely to come through the application of new technology, borrowed from other industries and applied to the farm situation. An example of this is the use of devices for monitoring activity as those used by Dr Nicola Blackie.
Inevitably there will be new challenges presented as we solve the old. A good example is the development of hock injuries in certain housing conditions. It is important that we can identify and understand the new challenges as they appear to give industry the best chance of responding effectively in this competitive and rapidly evolving industry.

CHAIRPERSON'S INTRODUCTION (cont.)

With current levels of lameness the commercial opportunity is potentially enormous. Events like today will, all going well, inspire uptake of lameness control concepts. It is usually through innovation underpinned by sound science that the most commercially successful products and services are developed and that the future of lameness control becomes self-sustaining. The last year was a year of activity; 2011 and onward looks set for growing commercial innovation.

Nick J. Bell
Chairperson of the Cattle Lameness Conference, Royal Veterinary College
On behalf of the CLC Organising Committee

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Royal Veterinary College
***The* Dairy Group**
University of Nottingham

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2011

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PAPERS

Proceedings of the Cattle Lameness Conference (2011) Sutton Bonington, pp 1 - 11
Royal Veterinary College, The Dairy Group and University of Nottingham

THE IMPACT OF NUTRITION ON LAMENESS - A REVIEW

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SUMMARY

While the diet offered to the dairy cow has an influence on lameness, this effect is complex. We now believe that this effect is mediated more through the environmental challenge to the foot of the cow rather than through the direct effect of the diet on the cow and her claws in terms of nutrient flow and either by-product or toxin formation. While we cannot rule out the effects of the last two factors we consider the interactions between the development of the claw in the young animal, the subsequent biomechanics of the claw, management and presentation of the diet (whether housed or at grass), and the effect of all these on the surface the cows walks upon are the most important areas to consider in relation to lameness in the dairy cow. While good life-time nutrition is essential as a lameness preventive, its relationship with other environmental, managemental and genetic risk factors and their interaction is the major determinant of claw horn lameness. A tentative 5 point plan based on the above is proposed including genetic selection. Hopefully the genetic initiatives in the Norden lands will encourage the dairy industries in other countries, including the UK, into similar action.

INTRODUCTION

For as long as man has domesticated cattle they have suffered from lameness. However, it was not until the latter part of the last century when, with the increasing intensification of our farming methods for the dairy cow, our interest in the condition has really blossomed. Initially this was led by veterinarians, epitomized by Toussaint Raven (Toussain Raven et al., 1985) and then followed by animal scientists and foot trimmers. There have been two reasons for this interest. Firstly there is the economic effect of lameness on the dairy cow estimated to give "avoidable losses" of around £25 to £30/cow in the average herd – note "avoidable"- some cows are inevitably going to become lame. It is the correct balance between control costs and lameness losses that we need to seek. At present these losses could certainly be reduced (Logue et al., 2003). Secondly there is welfare – lameness is painful, moreover it is very visible to the public, especially for those farms that still graze their cows. However, as with the pig and poultry industries, those who think permanent housing can hide such problems are mistaken as the recent controversy over large dairy herds has shown (Huxley & Green, 2010; Anon, 2011).

Some years ago nutrition was considered the major risk factor for lameness and in particular claw horn lesions. A plethora of papers seemed to confirm this, (for review of papers available at that time see Vermunt and Greenough, 1994). However slowly, it has become apparent that the influence of nutrition is much more subtle (see review by Logue & Bergsten, 2007). This is a much more difficult message to convey than a simple one saying "too much concentrates" yet this is where today's information is leading us. To review this fully means a number of non- nutritional areas need to be discussed.

THE PROBLEM OF DEFINITIONS

First of all when is a cow lame? Practice makes perfect but even then there are difficulties in deciding just when a cow is JUST lame. With all the different types of locomotion or mobility scores (MS) being used it would be good if we could agree a consistent form. The University of British Columbia has examined this dispassionately over a number of years and come up with an excellent set of guidelines for 5 categories of mobility with category 3 being the start of lameness (Flower and Weary, 2009). It may be that the use of cinematography, measurements of the position and/or forces between the feet and the ground will bring more objective measurements to this area. A relatively simple force plate methodology is available for field use in cattle (Tasch and Rajkondawar, 2004). Sadly however this potentially very useful methodology has yet to prove any better in the field than the trained observer (Bicalho et al., 2007). As this and even more complex engineering and video-based techniques are still evolving (Schmid et al., 2009; Walker et al., 2010) there is hope that more objective techniques will eventually be available and applicable in the field alongside a number of other automated dairy management systems such as milk yield, milk composition and progesterone concentration (by in-line monitoring), liveweight and body condition scoring and various behavioural monitors especially for oestrus detection.

Despite the pitfalls of a simple observer based system if we do not start "bench marking" lameness by MS we will never make progress! Reliable bench marking between various operatives will take some time both in terms of agreeing a system and making it as repeatable as possible. To at least stimulate some interest in making this endeavor more meaningful an estimate of the proportions of cows in each of five mobility categories in the UK is given in Figure 1. In rough terms this would equate with 75% green 20% orange and 5% Red in the "Tesco System". This suggests that at the moment in the UK roughly ¼ of cows have "poor" mobility at any one time and 1 in 20 requires immediate examination. It will be interesting to compare these estimates with the actual TESCO figures.

However prevalence is only half the story; incidence is also essential. Sadly, apart from a few well surveyed herds, such data is difficult to acquire and again is subject to considerable operator variation surrounding which animals are examined and which feet. Further is this a lameness that REALLY has not been seen for the previous 28 days? Is the lameness due to a different underlying lesion? If the animal has several lesions that could possibly be causing the lameness which one is? In some cases there is and probably will always be doubt but as before we need to start somewhere. Overall these data also show lameness in dairy cattle is common and that in the UK at least ¼ of cows are treated every year for lameness and of these approximately a ¼ are treated more than once to give an overall figure of just over 30 clinical cases per 100 cows per year. However this is very variable between farms (from less than 2 cases to approaching 100 cases/100cows/yr. Again a reliable objective automated system operating say, on a weekly basis, would allow us a better measure of this figure.

Identifying the lame cow is only part of the problem. It is the lesion that is the seat of the lameness incident that gives us clues as to the most effective method of control. Thus the definition of when the cow is lame and what lesions are identified and which of these are considered to be the seat of the lameness is crucial in approaching and understanding the problem at a herd level. Review of a number of papers shows that lameness is attributed to a relatively few conditions and these are primarily associated with the claw of the cow including its associated areas of skin (Figure 2). It has to be said that there are considerable variations between surveys and while claw horn lesions (which in the UK are mainly on the outer claw of the hind feet) account for the majority of the diagnoses associated with foot lameness recent evidence suggests that digital dermatitis is becoming increasingly common. Indeed in some herds almost all cows have been found with lesions though not all are lame.

Controlling lameness has been made more difficult by the inexorable trend for increased herd size, more time spent by dairy cows on hard, unyielding, wet and dirty artificial surfaces and a move to larger, higher yielding cattle that have a high propensity to mobilise body fat and protein to manufacture milk. All these, at least in part, explain why we are "running fast to stand still" in terms of lameness control. A "Systematic literature review" of lameness has shown antagonistic viewpoints concerning risk factors occur and these lead to some confusion in the minds of those dealing with lameness on a daily basis – the farmer and the hoof trimmer. In addition the lack of consistency in approach by various authors and groups has made it extremely difficult to assign a weight to any one risk factor over another in terms of priorities for intervention (Hirst et al., 2002). However, usually one can discern a majority viewpoint, for example, in favour of foot trimming as a means of control and prevention (Logue & Bergsten, 2007). Research into practical methods of control is a high priority for both the industry and government policy makers and it is essential that all those involved understand these different problems fully and communicate their research adequately to the farmer, foot trimmer and veterinarian and especially the policy makers. Retailers are included in the latter group as they increasingly demand certain welfare standards from their producers.

THE BOVINE CLAW

Dr Susan Kempson introduced many of us in the UK to the intricacies of the bovine claw (Kempson & Logue, 1993). Suffice to say that it is an engineering miracle! In the past we have suffered from a tendency to draw parallels between this and the foot of the horse and leap to conclusions that have proved unhelpful. The most important differences to note are firstly obviously the cow has two claws on each foot; secondly the laminae (the main area of support of weight from the ground through the claw up into the bony column) are considerably less developed and especially so where facing the digital cleft of each of the claws; thirdly the bovine claw has a digital cushion or "fat pad", which is thickest under the heel and runs forward under the horn within the sensitive corium to roughly halfway to the toe primarily as a shock absorption mechanism, an equivalent to the frog of the horse.

LESIONS OF THE CLAW HORN

These are the most intractable type of lesion causing lameness, have the greatest economic effect and are the most difficult to treat and control. The variation in the type of claw horn lesion is dependent on the interaction of many of factors. Firstly we have the cow herself, the claw must have developed normally and be as fully functional as possible. This is controlled by genetics, nutrition and the environment the cow interacts with. It is very difficult – if not impossible – to dissociate nutrition from environment and this is an area that will be constantly returned to. For example, white line lesions appear to be more common in grazing cattle that need to walk along tracks to milking while sole ulcers are more common in housed animals (see review by Vermunt, 2004). Similarly loose-housed cattle have more cases of white line abscess, digital dermatitis (DD) and foul-in-the-foot than tied animals (Logue & Bergsten, 2007).

One critical risk factor that is often overlooked is that once a cow has become lame then she is much more likely to become lame in her next lactation. This applies to any of the claw horn lesions but has been shown to be especially the case for an ulcer on the bearing surface of the claw when the cow is approximately twice as likely to suffer from this same lesion in her next lactation as unaffected animals. Moreover, the site of the lesion itself is also very repetitive (Logue & Bergsten, 2007). Thus there is a very good reason why one should strive to prevent lameness occurring in our young cows rather than merely controlling it once it has arrived. This has implications for the costs of any lameness control programme allowing an extra spend for prevention.

For many years we have accepted that the cow suffered from nutritionally based laminitis in the same way as the horse. However there is increasing evidence that laminitis is not the most common underlying source of haemorrhages in the claw horn (*pododermatitis asceptica diffusa* or PAD) or at best is only a relatively small part of the phenomenon. It is widely accepted that, when severe, PAD is the precursor of claw horn lesions such as the sole ulcer where the horn and its basement membrane is breached and the corium is exposed to the environment. Some, including this author consider that PAD is indicative of direct insults to the sensitive coria of the bearing surface of the claw and not necessarily the result of laminitis. They argue that PAD is largely biomechanically induced by the activities of the cow and interaction of her feet with the environment and this is further influenced by the behavioural challenges associated with nutritional management and the link between that, the housing and/or grazing, feeding, walking and resting environment. It is admitted that there may be other factors involved in the development of these lesions possibly including gut metabolites and disease-induced toxins even though these are not as well-defined (Logue & Bergsten, 2007). For example, there are considerable nutritional and physiological changes associated with the initiation of lactation in addition to the surface the cow walks on (Tarlton et al., 2002). The results from a systematic review of these risk factors has shown that evidence for many are by no means as clear-cut as some suggest and are so interrelated that disentangling them, especially using field data is far from easy (Hirst et al., 2002). This is a problem that has been recognized for a long time (Smit et al., 1986) and we have been remiss in failing to meet the need to design studies in such a way that we can use meta-analysis to combine different studies to give a better chance of significant findings.

LESIONS OF THE SKIN OF THE CLAW

In the early 1970s in the UK the only "skin lesion" of the foot regularly reported associated with lameness in the cow was foul-in-the-foot (FIF). However since then there has been an exorable rise in bovine digital dermatitis (BDD) first reported as an entity by Cheli and Mortellaro in 1974. Although similar lesions to BDD were seen before this they did not appear to take the epidemic form now described throughout the world, but particularly so in those countries that house their cattle. Thus we have now 3 major "skin infections" of the foot BDD, Interdigital dermatitis (IDD) and FIF. All have a common risk factor in dirty underfoot conditions and it is BDD that is now the most common lesion associated with lameness in our dairy cows (Laven and Logue, 2006). Recently there is evidence that the self same treponemes associated with this disease are now found in non-healing claw lesions thus making the latter even more troublesome (Evans et al., 2011).

NUTRITION AND LAMENESS

General Comments

First of all the development of the foot starts while the animal is *in utero*. While there is considerable interest in the effect of *in utero* life on subsequent development of the individual in some areas of biology there is virtually nothing known concerning the claw of the cow although some have started considering it (Galbraith & Scaife, 2008). The horn is an adaptation of skin and is subject to the influence not only of required nutrients but also hormonal and local messenger effects that are all stimulated by the stresses on the horn from the environment. Normal development of the horn requires sulphur-containing amino acids in abundance, various macro-minerals such as calcium, micro-elements such zinc, copper and selenium and a variety of vitamins in particular A and those in the B group. Biotin (B_7 or Vitamin H) is frequently discussed (Galbraith & Scaife, 2008; Meulling, 2009). There is evidence of a positive effect of biotin supplementation of the diet on horn quality from laboratory-based studies (Geyer, 1998). As a result biotin, alongside other essentials such as sulphur-containing amino acids and zinc, has been sold in various feed supplements for cattle that are claimed to improve hoof horn quality and reduce lameness. However in the field the results have not been quite so clear-cut (Logue & Bergsten, 2007). One suspects this is because in the normal fairly well formulated diet of the modern dairy cow such deficiencies are unlikely to be so great as to instigate the level of hoof horn disruption that some other risk factors for lameness cause and so may well be subservient to the effects of the latter.

The Calf

While the evidence is limited, intuitively one believes that those cows that are reared in a well-controlled manner will have better hoof horn quality than those that are not. To this end we must start with the calf and work through to the adult cow considering their overall nutritional needs. The critical importance of colostrum feeding of the calf in the first few hours of life is well recognised as having a significant effect on subsequent performance (Dawson and Moss, 2009). Despite this advice, an estimated 15 to 20% of calves are considered to show a failure of passive immunity (FPI). While we have believed that the colostrum of most cows is adequate in IgG, that of the young Holstein-Friesian cow, housed in winter, and/or with a high somatic cell count runs a real risk of being low (Gulliksen et al., 2008). As a result the routine use of commercial colostrum as a standard "additional" supplement especially in larger herds with a greater turnover of cows and prolonged housing of lactating cattle may well be of value. These commercial products can be of particular value for herds infected with *Mycobacterium avium paratuberculosis* (MAP).

Recent research (Morrison et al., 2009) has shown that calves offered higher levels of "milk" solids (milk replacer @1200 vs 600 g milk powder per day) grew significantly faster. This coupled with the use of automated calf feeders has resulted in a considerable body of work on calf rearing variables such as volume of milk, protein content, etc. However, as yet, although intuitively one would think some controlled increase in inputs would be of value, there is still little evidence from commercially based dairy units to indicate that this extra input results in any longer term benefit (Morrison et al., 2009).

The Dairy Heifer

The same intuitive reasoning applies to the dairy heifer where recent studies (Carson et al., 2000) have shown that growth rates up to 0.95 kg/day are possible in the Holstein-Friesian breed without compromising subsequent performance. There are some reservations about this advice since we know heavier adult cows are more likely to become lame but the consequence of limiting intake too much and affecting fat deposition may well be important for the development of the digital cushion. In addition if these young animals have inadequate feed face access there are added biomechanical consequences (DeVries and von Keyserlingk, 2009).

Just how the animal is reared and the environment that it is exposed to prior to calving can result in a subsequent effect during lactation. It would seem this effect is not mediated directly by diet but rather by the housing and/or feeding environment the animals were kept in and how they (and their genetics) interact with it and with the subsequent lactation grouping (Carson et al., 2004; Logue and Bergsten, 2007; Baird et al., 2009). There are further behavioural influences. Heifers need to be trained to the systems of housing and feeding that they will be exposed to post-calving. This will not only ensure they obtain adequate nutrition at a critical time but it also ensures minimum environmental challenge. For example, it is evident that a lack of "training" of animals to cubicles and the milking cow feeding system results in poor lying behaviours so predisposing to lameness. In addition there is information that habituation of heifers to the parlour prior to calving is advantageous, as is leaving them on a straw yard for some time post-calving prior to introduction to the cubicle shed with the main herd; though just how long this is needed for maximum economic effect is uncertain (Logue and Bergsten, 2007). There is also some preliminary information that, not only is it best to it is best to introduce freshly calved lactating heifers into the adult herd in pairs (at least), but the evening is better than the morning (O'Connell et al., 2008; Boyle et al., 2010).

The Transition Cow

Roughly 1 in 10 dairy cows are treated for some illness during the periparturient period. Digestive disorders, retained placenta, milk fever, metritis, mastitis and lameness can all be related to the events occurring around calving, including the nutritional management. Feed intake during the periparturient phase to maintain both rumen fill and function is of critical importance in the aetiology of pathological conditions of the gastro-intestinal tract, and it is well known that overfat cows at parturition have a lower intake than normal. In addition many other diseases can be related to events prior to calving, indeed some, such as retained placenta and subsequent metritis, have a clear connection to dystocia and milk fever. Dystocia itself is often ignored and poorly recorded despite its relationship to other conditions (Logue & Bergsten, 2007).

The overall objective of nutritional management during the dry period is to prime the cow for the increased mobilisation of body reserves that occurs in early lactation. How best this is done is still subject to considerable anecdote. High body condition at calving (score 3 plus) results in reduced food intake in early lactation and increased rates of tissue mobilisation and Garnsworthy (2006) argued that a lower BCS target (2.5) at calving was necessary for the modern dairy cow. However it may be that slightly higher levels of condition at calving are required for pasture-based systems (Roche et al., 2009). Such control is best undertaken prior to drying off as it is difficult to achieve a major effect on body condition during the relatively short dry period (approximately 2 months), which has many other constraints on intake and the maintenance of cow health.

Many dairy units, especially the larger ones are now applying specific "transition" diets in the last 3 to 4 weeks of gestation. This is restricted to approximately one third of the milking cow ration (including forage) and is usually fine-tuned by introducing straw, increasing the proportion of rumen undegradable protein, restricting dietary calcium and enriching with magnesium. We have already said that these macro and micro-elements are essential for good claw horn production but we have no idea how to optimize this. Finally an alternative macro-element strategy is to control calcium metabolism though manipulation of dietary cation-anion balance (or difference) (DCAB). This is most applicable to herds housing all year round and its relationship to lameness is uncertain. Nevertheless the nutritional, behavioral and environmental changes during this period between drying off and the initial part of lactation are of great significance for the extent of lameness in the herd.

Lactation Inputs

While many investigations have implicated high levels of concentrate in early lactation as a risk factor for subsequent claw horn lesions, the evidence for a direct link between diet and lameness in herds when nutritional management is based on modern nutritional programmes is now being questioned (Carson et al., 2004; Logue & Bergsten 2007). Some authors also comment on the importance of ruminal acidosis and in particular subacute ruminal acidosis (SARA) in the aetiology of lameness. However, just how one defines SARA is not altogether clear and in one episode of severe clinical acidosis in a group of cattle, which were then monitored for foot health no link between the incident, the severity of the clinical condition (some cows became recumbent) and subsequent claw horn lesions could be discerned (Offer et al., 2004). However laminitis has been confirmed in the cow, albeit in pure bred beef heifers at grass, (Kempson S.A. pers.

com. 1998) and Greenough in 1997 described a "grass founder" so while these types of incidents appear rare we need to keep an open mind about the possibility of gut metabolites and disease toxins affecting the laminae. Further while high forage diets are generally associated with a higher rumen pH, well-fermented but wet silages can increase the acid load on the rumen. In addition their wetness reduces salivation and water intake, so appropriate concentrate supplementation is critical, as is access to water so we are NOT saying do not think about nutritional inputs merely that the cow is pretty amazing and can cope with quite a variety of these without feet being a major concern as long as long as all the other factors discussed here are considered!

One aspect of poor gut function is "loose faeces". There is a lowering of immunity associated with calving and this along with high stocking rates (as when housed) loose faeces and dirty underfoot conditions seem to be the prime movers in the severity and spread of digital dermatitis. Thus in this respect diet is of importance, as environmental contamination by these loose faeces, especially in housed cows, is a very real problem for many farmers and their veterinarians. Control of BDD is limited to improved underfoot conditions, regular footbathing and in severe cases individual treatment. So far it appears that 5% $CuSO_4$ is the best of the available products for footbathing though several others have been evaluated (Speijers et al., 2011)

As we have already discussed, for the cow and especially the heifer the management of introduction of the adult cow into the competitive arena of the milking herd is often neglected in the hustle of a busy herd at peak calving periods, yet this is critical. The energy demand of an average UK dairy cow almost triples from before calving to peak lactation so it is hardly surprising that she has to mobilize body fat to underpin this demand since she cannot eat sufficient food especially if much of it is grazed forage. Fat reservoirs are related to body condition score (BCS) and the cow best able to respond to these demands is the one in "fit condition" (i.e. 2.5 to 2.75 BCS) compared to both low BCS and high BCS at calving, the former for the prolonged time for BCS recovery, the latter its greater BCS loss post-partum. Both have been associated with lowered fertility and other health problems including lameness. We have become increasingly aware, there are genetic and endocrinological differences in internal fat metabolism and deposition both within the cow and between types and breeds. One area of importance in relation to lameness is the digital cushion of the claw, which is heavily impregnated with fat. Recently Bicalho *et al.,* (2008) looked at the thickness of the corium by ultrasound below the site of insertion of the deep flexor tendon as a measure of the size of this structure (Digital Cushion Thickness or DCT) and found that, firstly DCT was directly related to BCS, secondly DCT dropped quickly post calving and reached a nadir at around the 4th month of lactation and finally that this thickness was inversely related to the presence of claw horn lesions such as sole ulcers and white line lesions. Whether these DCT changes can be ameliorated by specific nutritional inputs remains to be seen.

A further aspect often ignored for the newly introduced cow is her access to food and water and the fact that she may be asked to either stand for too long or walk too far for milking. The cow really needs to be cared for during this period and the use of an "introductory post parturient group" that is given preferential room and good access to a specific early lactation feed formulation, is increasingly being used in larger herds to ensure that the cow is given the best possible chance to adapt to these demands of lactation (Logue and Bergsten, 2007). This can be done at grass as well with newly calved cows being asked to walk less and given better grazing. Should the cow be housed then housing comfort, not only in terms of lying accommodation (sand cubicles are all rage at present), but also all the other aspects of daily living need to be considered, not least the floor surface. The overall challenge from hard, wet, abrasive surfaces such as concrete is increasing in the UK at a time when genetics and management is making the claw less able to withstand such an environmental challenge. This challenge is also evident when grazing with larger numbers of cows as these require longer and better walkways, access to adequate water troughs and of course a palatable sward of sufficient length.

CONCLUSION

In short while good life-time nutrition is essential as lameness preventive it is its association with other environmental, managemental and genetic risk factors and their interaction that is the major determinant of claw horn lameness. A tentative 5 point plan for controlling lameness first promulgated at the IDF in 2007 is shown below

1. Identify, treat and record all lame cases immediately using these records to target the most appropriate risk factors including those below.

2. Ensure good claw shape and health by good nutritional management and regular foot trimming (including recording of lesions).

3. Reduce environmental challenge to the foot by attention to detail with:-
   i. Regular foot-bathing
   ii. Clean, dry, well maintained walkways /tracks.
   iii. Strategic use of rubber or other yielding surface on walkways.
   iv. Adequate comfortable lying area for every cow.

4. Ensure well balanced food and water with adequate access for every cow.

5. Select for sires whose daughters have a proven record of good foot health

With regard to point 5 hopefully the genetic initiatives in the Norden lands will encourage the dairy industries in other countries including the UK into similar action (Logue and Bergsten, 2007).

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Figure 1. A summary of some mobility scores from a number of dairy herds in the UK "converted" into the University of British Columbia mobility scoring system (UBC MScore)

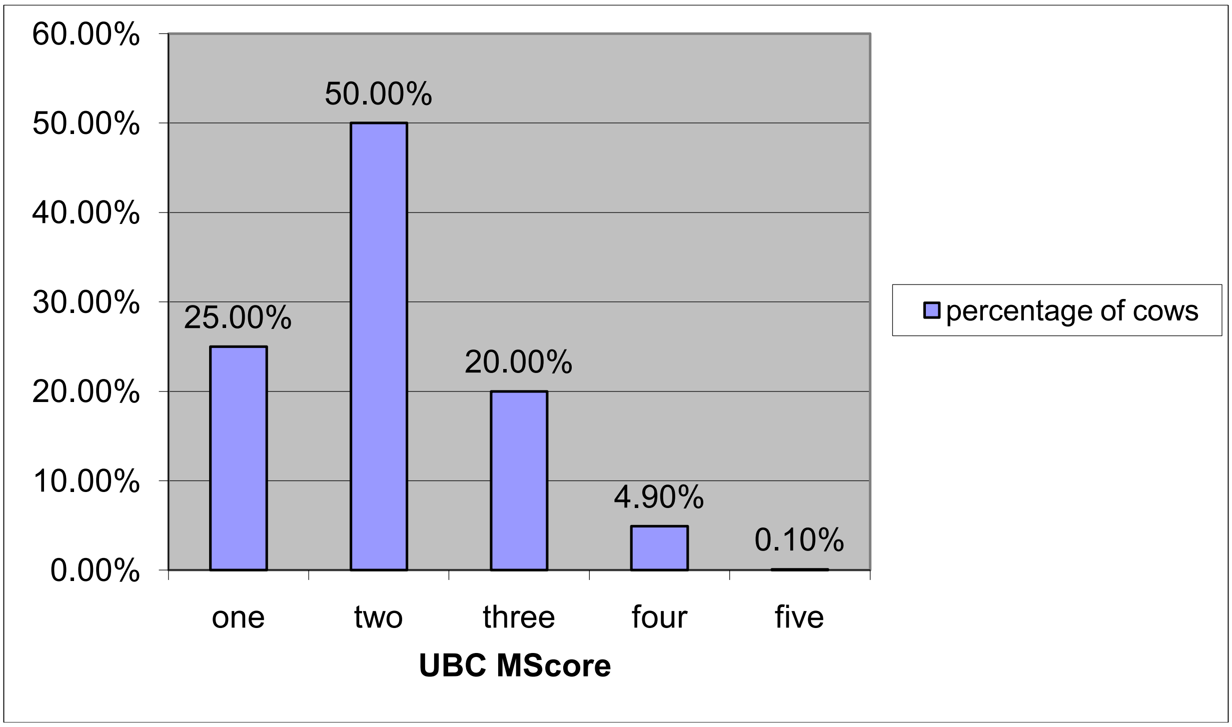
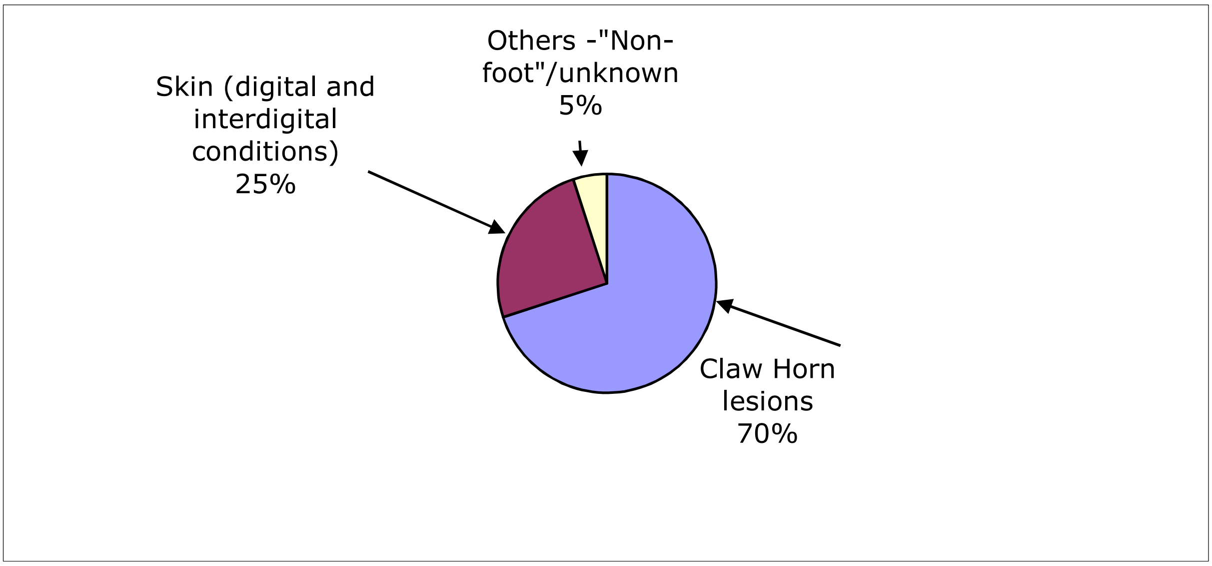


Figure 2. Likely overall percentage of lameness lesions in UK dairy herds categorised into 3 basic types, claw horn, skin and others.



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COW TRACKS AND COW FLOW AND HOW THEY APPLY TO LAMENESS

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SUMMARY

Footwear, occurring as cattle are handled on the hard surfaces of cow tracks and concrete yard areas makes the sole and white line vulnerable to injury. This is the primary precursor to traumatic lameness in New Zealand pasture fed dairy cattle.

When cattle are poorly handled on hard surfaces further wear and damage can occur. Poor cow flow and lack of patience of herdspersons will result in sole injuries on the track, and white line separation in the milking area. Problems with facilities can cause poor cow flow, but good stockmanship can improve this. On the tracks cows should move freely and voluntarily. In the milking parlour understanding the behaviour of cows and establishing consistent routines will improve cow flow and efficiency, and reduce lameness.

Footwear and subsequent lameness can result directly from the state of cow tracks. Wear, even on well maintained tracks, will be exacerbated by the distance that cows walk to and from the paddock to the milking area each day. Some recent studies the distance that cows walk on hard surfaces show that, depending in the grazing system, cows are walking very long distances, with the average daily distance varying from 1.3 to 5.47km.

If wear and cow flow can be well managed then we can expect to see reduction in lameness.

INTRODUCTION

Lameness in pasture fed dairy cattle begins with foot wear on tracks and in the concrete holding yards. Footwear alone doesn't necessarily result in lameness, but makes the claw much more vulnerable to physical damage.

Early studies in New Zealand (1) showed that lack of track maintenance and impatience of herdspersons are two of the most important risk factors for lameness in pasture fed animals. Impatient handling and poorly maintained tracks will also cause more wear. In this talk I will be focusing on these two factors and the latest direction we are taking with finding possible causes for foot wear and subsequent lameness due to the distances that the cows walk each day.

FOOTWEAR

Beef cattle on pasture have almost no footwear. They have a concave sole with weight bearing on the walls of both axial and abaxial claws. This is the same with dry cows and heifers on pasture where the walls bear the weight. However, when the cow or heifer calves and enters the herd and starts walking on tracks and concrete yards, the wall wears down faster than it is growing for the first 110 days (5) and the animal's soles flatten to the point that the sole on one or both claws may be bearing weight. This is "normal" for the cow walking from the pasture to the milking parlour on tracks.

On many farms the tracks are poorly maintained. This is the first risk factor found in our Taranaki Studies (1). This damaging walking surface exaggerates sole wear.

Once the sole is thin we have a more vulnerable foot and any excessive wear, poor surfaces or poor handling will result in sole and white line lameness.

When there is an outbreak of traumatic lameness look first for the cause of sole wear and then for the extra exacerbating factors

COW FLOW ON THE TRACK

The second risk factor we found in our Taranaki Studies (1) was impatience of the herdsperson. Poor cow flow (or at least perceived poor cow flow) on a track often causes impatience in the herdsman. Instead of allowing the cows to flow voluntarily and so be able to carefully place their feet, the cows are compacted and the foot damage is exaggerated. Small stones on the top of bigger stones, or stones carried onto concrete, bruise (at best) or puncture the flattened/worn soles.

What is good cow flow?

When we talk about cow flow we are talking about the herd rather than the individual, but what affects the individual – eg tight corners, stray electricity, will also affect the whole herd. Cow flow is "good" when the herd flows voluntarily and smoothly along the tracks, into the holding yard and through the milking parlour. Most medium sized New Zealand herds of up to 500 cows will, with good cow flow, come "home" from the paddocks in 20-30 minutes and be milked through the parlour in 1 ½ - 2 hours.

How can we achieve good cow flow on tracks?

1. Stockmanship

Cows walk out of the paddock and settle into a fairly stable order as they move along the track. Leader cows and dominant cows set the speed of walking – the rest of the herd just follows.
Cows must be allowed to flow at their own pace. The stockman follows keeping far enough behind the last cows to ensure the rear cows don't bunch up. He calls out or talks to the cows to encourage them to keep moving.

2. Facilities

The design of tracks determines the voluntary walking speed of the herd. Where cows have a well drained, non abrasive surface to walk on that is wide enough for the size of the herd the average flow rate may be up to 4.5km per hour.
Sharp bends and narrowing of the track, loss of the fine top layer, poor drainage and gravel on concrete all cause disruption to the flow of a herd.
The most common problem area of tracks is at the junction with concrete. Water pools, fine materials are washed away and gravel is carried onto the concrete. Cow flow dramatically slows down if this area is not maintained. A transition material such as limestone fines for 30 – 50 metres before concrete surfaces dramatically speeds up cow flow into the holding yard.

COW FLOW IN THE MILKING FACILITY (Yard and Parlour)

Poor cow flow in the milking yard (or at least perceived poor cow flow) also causes impatience. This is common where milking times are longer than 1 ½ hours. Some herds in New Zealand may take 2 ½ - 3 hours or more because of poor cow flow. Instead of allowing the herd to flow voluntarily into the parlour, gates are used to push the cows, or people go in among the cows to try and speed up the flow.

Both these responses (the backing gate and going out among the cows) will result in foot damage as they cause cows to push up against each other and to twist and turn on the hard concrete surface. This cow-response to pressure in the yard puts pressure on the white line as the cows adjust their stance. The white line is one of the weak points in the structure of the foot – it separates slightly.

In higher dominance cows the pressure is put on the rear outer claw. In lower dominance animals the response to pressure is on the front inner claw. The resultant injury is separation of the white line. In approximately 70% of cows and heifers with white line separation the injury is bilateral, even if the contra lateral side is minor.

If gravel is forced up the separated white line, infection and abcessation forces its way under the wall. The (opposite) second side is not necessarily lame – but the separation is present and ready just for stones to be pushed in.

How can we achieve good cow flow in the milking parlour?

1. Stockmanship

As the herd arrives at the milking parlour the milking machines should be going. The first cows should be allowed to enter the bails and be milked on arrival. The cows entering the holding yard will start to readjust from a walking order to a milking order (2). Cows need space to do this so the backing gates should not be used to reduce the yard area for at least 15 to 20 minutes after the last cow arrives. The cows' heads should all be down while they are standing in the assembly yard. Milkers should not come out of the milking parlour to gather cows as this also disrupts the milking order. In herring bone sheds the milkers should commence cupping at the front of the shed – the opposite end to the bail entrance. The backing gate should not be used to push the cows towards the milking bails – it should only be used to gently take up space as the cows move forward. If motorized backing gates are used they must move forward a maximum of one metre at any one movement. The milkers should talk to the cows – calling them into the bails with one command using a gentle higher toned voice, and use a different command to tell them it is time to leave the milking parlour. Ideally these two commands – "calling" and "sending away" should be the same commands that are used with the younger stock – calves and heifers so that when they join the herd they are already trained.
New staff coming to the farm should be taught the commands and the correct tone of voice.

2. Facilities

The most common problems with the collecting yards are:

i. The entrance is in the wrong place in relation to the bail entry.
ii. The collecting yard is too small for the number of cows (min. 1.8 sq m per Holstein cow).
iii. The concrete is slippery.
iv. Concrete slopes are too steep.
v. Sideways slope of the concrete approaching the milking parlour or on the exit.
vi. Sharp bends.
vii. Dark sheds.
viii. Stray electricity.
ix. Poor gate designs – motorised backing gates that are too fast (12m/min in round yards, 6 m per min in rectangular yards).

x. Sharp turns at the exit from the bails (minimum of 4 metres turning area).
xi. Pipework that will injure hips.

Where there are design problems on the track and in the milking parlour area it is still possible to achieve reasonable cow flow if the stockmen understand where the problems are. Patience is the answer until the facility can be upgraded.

Because cows are "creatures of habit" improvements in stockmanship may not result in immediate improvement in cow flow. Our experience is that retraining usually takes 4 to 6 weeks of determination with the older cows. The younger cows learn more quickly.

COW TRACKS

A large portion of the footwear suffered by walking cows occurs on the tracks.

What sort of tracks do we need?

The Ideal track

i. short - less than 1 km long.
ii. wide - recommended widths for tracks.
   <120 cows - 5m
   120 - 250 - 5.5m
   250 - 350 - 6.0m
   350 - 450 - 6.5m
   450+ - 7.0m+
iii. level.
iv. straight.
v. even width track - no congestion points.
vi. crowned surface of 3-5% (max 8% slope).
vii. non-abrasive top surface of fine material.
viii. drained on outside of fence (paddock side).
ix. widens out before shed (extra 1 metre).

Simply walking on hard surfaces by itself will cause wear. However, if the tracks are poorly maintained then definitely there will be extra wear.

Whatever state the tracks are in, wear will be exaggerated by long walking distances. So an extra factor in foot wear and damage that we are investigating now is the distance cows walk. We are at present carrying out a study on the distances walked by dairy cows in New Zealand on hard surfaces each day. Preliminary results were presented at the Lameness symposium in March 2011. (3)

When investigating lameness problems in 3 large dairy farms (600-1400 cows), each with two herds of cows, it was found that the lameness incidence and prevalence was markedly different between the two herds on the same farm. In fact, only one of the herds on each farm had a significant problem. Both herds were milked through the same milking yards and parlour, but were grazed at opposite ends of the farm. The maintenance of the tracks was similar for both herds. The main difference in every case was the difference in the daily distance walked along tracks between the milking facility and the paddocks.

Table 1: Annual Incidence of Traumatic Lameness in selected split herds

Farm #	Herd 1	Herd 2	Total cows
1	1%	17%	1400
2	6%	50%	850
3	8%	48%	600

The aim of the present study was to collect data from farms in Taranaki to answer these questions:

1. How far do cows walk on track surfaces per day?
2. What are the average daily distances walked?
3. Is the distance walked fairly consistent every day, or are there some days (or even groups of consecutive days) where the distances are particularly long?
4. Are there key questions that will predict whether a farm is likely to have longer daily walks at some stage during the grazing rotation (and therefore increased foot wear)? For example length of longest track, grazing pattern (intentionally alternating 12 hours near/far paddocks (N/F), random choice of paddocks morning and night (R), same paddock morning and night (24 hr)), position of milking parlour, once-a-day milking (OAD) vs twice-a-day (TAD) milking.

Table 2 summarizes some of the results so far.

Table 2: Summary of distance study results

	Range	Average	Median	Standard Dev.
Farm size	31 – 205 hectares	101 hectares	91 hectares	35.9
Herd size	100 -545 cows	278 cows	250 cows	93
Track length (longest track)	0.8 – 3.00 km	1.50 km	1.40 km	0.45
Average daily walk	1.33 – 5.47 km	3.00 km	2.93 km	1.1
Max distance in 1 day	2.42 – 10.00 km	5.03 km	4.95 km	1.6
Max distance for consecutive 5 day period	8.19 - 44.0 km	20.63 km	19.6 km	7.1

This walking distance study only looked at the grazing round immediately after the majority of the seasonal herd had calved. This round is a crucial round because it would involve the whole farm using the full length of the tracks. The distances walked would incorporate the longest sections of the track. It is also a crucial round because it is within the first 100 days after calving when the cows are adapting to hard surfaces after wintering on pasture (3,4). It is also a crucial time when foot wear will be tested as cows start to come into oestrus.

Questions regarding length of longest track, position of the milking parlour, the grazing pattern: OAD or TAD with 24 or 12 hour grazing, size of herd and farm were all considered possible questions that might be predictors of longer walking distances.

Average distance walked varied as would be expected according to the layout of the farm. Most farms had multiple tracks, but the longer the main track was the further the average daily walking distances. Also important was the position of the milking parlour, with a more central position giving shorter walks when compared with milking parlours situated on the edge of the farm (when the length of the main track was the same).

Neither the herd size nor farm size were good predictors of distance walked within the range studied.

The OAD milking pattern not only halved the average distance walked, it also dramatically reduced the time spent on concrete surfaces of the milking yard. Anecdotal stories of dramatic drops in lameness when a herd is changed from TAD to OAD milking may suggest that the extra time on soft pasture allows recovery of the sole each day from track damage even if the walking distance is quite long. Other advantages could be the more comfortable walk in the cool of the morning (most OAD herds are milked in the morning) compared to the afternoon heat.

12 hour grazing compared with 24 hour grazing in TAD systems was a crucial question. The results show that 24 hour grazing patterns will result in longer walks generally, because the cows were forced to walk back to the same distant paddocks. With 12 hour grazing the herdsman could chose (as is usual in NZ) to have a close paddock alternating with a further paddock every 12 hours. A second effect seen in the 24 hour system was when the manager failed to use a close paddock on alternate days due to "following the grass". This resulted in some groups of 5 consecutive days or more where the daily walking distance was excessive. This effect also occurred on the 12 hour farms especially where the pasture management system followed the grass. This practice of choosing to follow the grass, rather than considering the distance walked, could be a tipping point in foot wear.

There needs to be quantitative work done on the amount of hoof wear the cows are suffering in relation to the distance they walk on hard surfaces. It may be that early in the season cow soles are more prone to wear as they adapt to hard surfaces after their winter spell on soft paddock surfaces. Is there an upper limit to the amount of walking that soles will tolerate without becoming so thin that lameness will result?

Study Conclusions

The average distance a cow walks daily on hard track surfaces is directly related to the length of the longest track, but also depends upon the layout of the farm, and the grazing pattern. If we believe that cows are suffering excessive foot wearing due to long distances walked there should be recommendations on length of longest track, farm layout and grazing patterns.
Further studies are needed in order to measure changes in the thickness of the soles of dairy cattle with walking distances, and the relationship of this to lameness.

CONCLUSION

Trauma to the soles and white lines is the most important cause of foot lameness in pasture fed dairy cattle.

The claws are remarkably resistant to trauma while the soles remain thick. Wearing of the soles on hard, long tracks predisposes a foot to both sole penetration and white line separation. When there is poor cow flow on either the farm tracks of on concrete waiting to be milked impatient herdsmen are more likely to put pressure on the herd to try and speed up the movement. This results in an increase in unplanned foot placement and increased trauma and lameness.

So in summary:

Foot wear on track = thin soles
Thin soles + poor cow flow on track + impatient herdsperson = sole bruising and sole penetration
Thin soles + poor cow flow in milking parlour + impatient herdsperson = white line separation

Therefore if wear and cow flow can be well managed then we can expect to see reduction in lameness.

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Proceedings of the Cattle Lameness Conference (2011) Sutton Bonington, pp 21 - 34
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TECHNOLOGY AND BEHAVIOUR: STUDIES OF LAME COWS

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SUMMARY

This paper presents a series of experiments that explored the gait attributes commonly utilised in subjective locomotion scoring systems and use new technology to evaluate these gait attributes objectively. Kinematic gait analysis more commonly used in sports and equine science was adapted for use on dairy cows to assess stride characteristics, joint flexation and spine posture in dairy cows with different lameness status. The effect of locomotion score on lying behaviour of cows was also assessed using IceTag accelerometer devices.

Cows that were lame had shorter stride length, moved more slowly, had negative tracking distance and showed numerical differences (NS) in spine posture when walking. The latter changes were more evident in cows with sole ulcers, which showed lengthening in the thoracic and shortening in the lumbar regions of the spine and showed significant shortening of the spine when walking and had a lower head position than cows with no hoof lesions.

Lame cows (locomotion score 3) spent an average of 2 hours longer lying down per day compared with non-lame cows; they also had similar numbers of lying bouts however, duration of lying bouts was greater. Lame cows spent longer lying down in the evening and spent less time lying between 12am and 3am, perhaps to avoid conflict.

INTRODUCTION

Lameness in dairy cows is a considerable problem in the UK dairy industry as well as worldwide. The prevalence of lameness is around 25 % of cows with 39 % of zero-grazed cows affected in the UK (19). Lameness is a painful condition which may last many months and therefore has welfare implications particularly when not detected and/or treated promptly. Not only is lameness detrimental to animal welfare; it reduces the profitability of dairy enterprises. Lame cows produce less milk, are often in less good body condition in comparison to non-lame cows (10). Lameness also impacts the fertility of cattle whereby lame cows are often harder to get into calf through reduced oestrus intensity with lower follicular phase oestradiol (9). Lame cows often require more serves per conception and have extended calving to conception intervals compared to non-lame (17, 21, 22, 41, 45).

Lameness manifests many gait alterations including shorter stride lengths, negative tracking distances and altered hoof flight patterns (13,46). These are often assessed using locomotion scoring systems. These have been widely used in dairy research since the development in the late 1980's. However, locomotion scoring can be time consuming and subjective although easy to use and quick to learn. Locomotion scoring systems incorporate stride length, tracking, joint flexation, spine arch (45) and Manson and Leaver system includes the behaviour of the cow to assess lameness.

Kinematics is the branch of biomechanics concerned with the description of motion. It has been used in equine science to assess the gait adaptations related to lameness (1, 36, 37, 39, 40, 48), predict future performance (3, 44) and test the effects of nutritional supplements on joint flexation (33). Kinematics have also been used to assess gait of dogs (47) and in cattle in a variety of experiments assessing housing lesions and milking. To quantify the gait, including joint flexion and stride characteristics of an animal using kinematic assessment, markers are attached to the centre of rotation of the joints. These techniques are less subjective than those dependent on human opinion such as locomotion scoring but require adaptation to be used on farm routinely.

To date kinematic gait analysis has been used to assess the impact of flooring and housing on the movements of dairy cattle (20,46). It has also been used to assess the impact of milking and pain relief of cattle (14). A further study has documented the effects of sole ulcers and sole haemorrhages on gait (13); however, to the author's knowledge, there has been no work quantifying the impacts of other hoof lesions.

Lameness also influences the behaviour of dairy cattle; lame cows spend longer lying down than their non-lame herd mates. The behaviour of the cow before lameness develops may also be a risk factor for the development of lameness whereby cows showing long periods of standing may be more likely to go on to develop lameness (25,26). Lame cows also tend to eat less often and may consume fewer meals (2,29,30). Severely lame cows show reductions in feed intake, it may also be possible to predict lameness through automatic monitoring of feeding behaviour before signs of lameness are seen (18).

This paper aims to summarise a number of studies which quantify the impact of lameness and specific hoof lesions on kinematic measures of gait and lying behaviour in dairy cattle.

MATERIALS AND METHODS

Gait Analysis

Gait analysis uses the study of kinematics; methods were developed from those used in sport and equine science to objectively describe the gait of the cattle. The centre of joint rotation is marked using cardboard markers, the cow is then filmed walking past a camera and a computer gait analysis program is used to process the videos. Attempts were also made to quantity back arch using 4cm diameter plastic balls attached over the spineous processes. Details of methods follow:

Holstein dairy cattle (n=25, n=60 or n=80 for each study, respectively) were filmed walking along an alley (1.6m) constructed from traffic cones and electric fence posts with a heavy duty plastic chain connecting the cones. A digital video camera (Canon PAL MV690) was placed 15m perpendicular to the alley. The field of view captured using the video camera was 4.5 m. Filming took place following morning milking between 08:30 and 12:00. Yellow cardboard markers 3 cm diameter (Plate 1), were glued over the joints of the cows using contact adhesive (Evo-stick 528) as detailed in Table 1 and shown in Plate 1.

Table 1: The description of leg marker placements for gait analysis

Marker Name	Limb	Number	Location
Fore Coffin	Fore	1	On the coronary band close to the centre of rotation of the coffin joint
Fore Fetlock	Fore	2	On the condyle on the distal end of the metacarpal bone at the same height as the sesamoid bone
Knee	Fore	3	On the centre of the carpus between the lateral splint bone and the pisiform bone
Elbow	Fore	4	2 cm above the lateral tuberosity of the radius
Shoulder	Fore	5	On the caudal tubercle of the humerous, where the humerous articulates with the glenoid cavity
Scapular Spine	Fore	6	On the flat spot on the scapula spine, close to distal end
Hind Coffin	Hind	7	On the coronary band close to the centre of rotation of the coffin joint
Hind Fetlock	Hind	8	On the condyle on the distal end of the carpal bone at the same height as the sesamoid bone
Hock	Hind	9	On the flat spot on the talus
Stifle	Hind	10	2 cm above the head of the fibula
Hip	Hind	11	On lower point of the greater trochanter
Pelvis	Hind	12	On caudal point of tuber coxae

Clayton, Personal Communication, 2005

Each cow was then walked along the alley at her natural walking pace three or four times. The films were downloaded and cut into individual runs and each file was then saved as a DV-AVI file. The images were digitised using Simi Motion Analysis Software (www.simi.com, Postfach 1518, D-85705 Unterschleissheim, Germany). Simi motion analysis is a 2D gait analysis system primarily used for sports research.

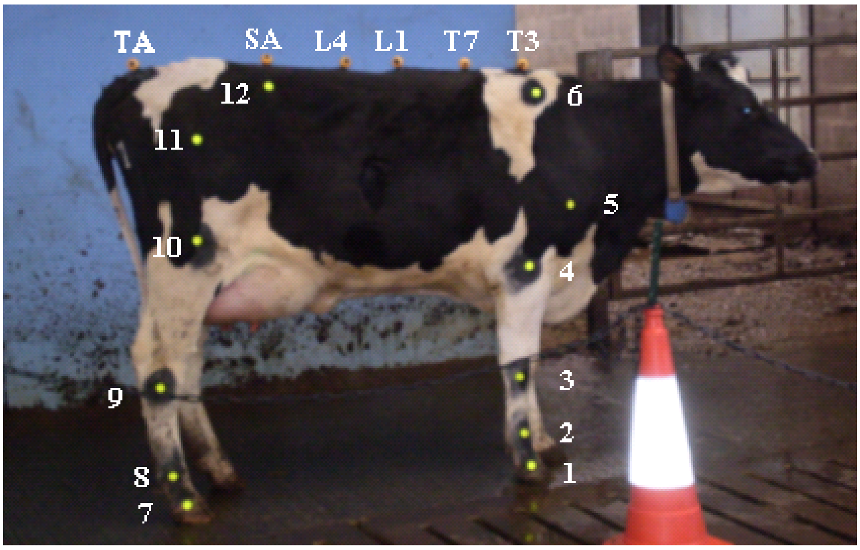

Plate 1: The joint markers used for gait analysis (3 cm diameter) constructed from fluorescent yellow cardboard discs. Spine markers were made from table tennis balls (4 cm).

Stride length was determined as the distance between the cannon appearing straight and the next occurrence of the cannon being straight for the fore and hind limbs. To calculate this distance the fetlock marker was highlighted when the cannon was straight then the film was moved on until the cannon was straight again and the fetlock marker was selected this allowed the distance to be calculated by the Simi software. Tracking distance was calculated as the distance between the fore foot being placed on the ground (selecting the fore fetlock marker) and the ipsilateral hind foot being placed on the ground (selecting the hind fetlock marker). A cow with perfect foot placement (where the hind foot is placed where the fore foot had been) would have a tracking value of 0 cm. A negative result indicates that the hind foot fails to reach the placement of the fore foot and therefore the cow is short-striding.

Wither height was measured while the cows were restrained in stalls using a height stick. Wither height was measured when the cow was standing square with her head elevated to prevent the cow dipping her back. The wither height of the cows was similar across locomotion score groups in each experiment which allowed stride length to be compared without scaling. Height of an animal can have an effect on all temporal stride characteristics (3). The distance between fetlock and elbow markers was measured for calibration of the films.

Spine markers were attached above the spinous processes T3, T7, L1, L4, the cranial end of the sacral vertebrae (SA) and on the tail head (TA) (Plate 1) these locations were adapted from the method of Licka and co-workers (27,28) and were selected to give an even distribution across the spine of the cow. The spine posture of each cow was assessed at full support; defined as the point where the fore limb was just seen to bear weight. The distance between each marker and the ground was measured. The length of the spine (standing) was calculated as the distance between spine marker's T3 and TA while the cow was standing square in the crush. The spine length when walking was measured in still mode of Simi motion analysis in a similar way to marker height when the cow was in full support. The difference between spine standing and spine walking was calculated to indicate the spine posture of the animal while walking.

Cow speed was calculated from the time taken (determined from the film) for the cows to pass through the field of view and the field of view which was 4.5m; the calculated as speed = distance/time.

Lying Behaviour

Standing and lying behaviour were assessed in the same population of lactating Holstein cows using activity monitors (IceTag™, Ice Robotics Ltd., UK) that were attached above the fetlock of the back right leg of cows for 4 consecutive days. Data from the IceTags were used to determine the percentage of time the cows spent lying, standing (still or moving), and active; the data were converted to hours/day. The mean duration of lying bouts was calculated as the number of consecutive minutes that the percentage of time spent lying was recorded as being greater than 90% (i.e. the cow had been lying down for 54 of previous 60 s). The number of lying bouts per day was determined as the mean number of times a cow lay down during a 24 h period. From the lying data, the minimum and maximum amount of time spent lying down each day was determined and the mean of 4 days of data was used for analysis.

Hoof Lesions and Locomotion scoring

The cows were assessed for hoof lesions within one week of kinematic gait analysis. This was because annual foot trimming session coincided with the experiments. During functional hoof trimming the presence of lesions (using "Lamecow" colour atlas, 24) and the severity was recorded. The lesions were allocated a score based on the observations as described in Table 2. All cows were locomotion scored using the method for scoring walking cows described by Flower and Weary (11) at the time of gait analysis. Briefly cows were scored walking past an observer (NB) and locomotion was scored from normal (Locomotion score 1) to severely lame (Locomotion score 5). Factors considered were degree of spine arching and weight bearing of each limb.

Table 2: Description of lesion scores used to assess hoof lesions of cows

Lesion Score	Description
1	Slight discoloration
2	Moderate haemorrhagic lesion
3	Severe haemorrhagic lesion
4	Exposed corium

(Flower and Weary 2006)

RESULTS AND DISCUSSION

Gait adaptations of lame cows

Data presented are from a number of studies undertaken on lame and non-lame dairy cattle. A summary of data from induced lameness in horses (where many kinematic assessments of induced lameness have been made) are shown in Table 3, along with data from previous kinematic studies of dairy cattle. Results from 3 studies are also shown in table 3; lameness had constant effects on the gait of cattle. Lame cows walk more slowly with reduced stride length and negative tracking. Lame cattle show decreases in hoof height and an increase in stride duration, converse to the gait adaptations seen in the equine.

Table 3: Summary of supporting limb lameness gait adaptations induced in the equine; compared with previous cattle studies of lame cows and findings of present studies

Equine induced supporting limb lameness (4,5,16)	Summary of cattle studies (13,46)	Experiment 1 n = 25	Experiment 2 n = 60	Experiment 3 n = 80
Decreased Speed	Yes	Yes	Yes	Yes
Decreased Stride length	Yes	Yes	Yes	Yes
Decreased tracking	Yes	Yes	Yes	Yes
Decreased Swing duration	No	-	-	-
Decreased Step length	Yes	-	-	-
Decreased Stride duration	No*		No*	No*
Increased Hoof height	No*	-	No*	-
Decreased Stride variation	-	-	Yes	Yes

* Opposite effect seen

In one study of lame cows, stride length was significantly 31 cm shorter (p=0.03) in cows with sole ulcers in comparison to cows with no lesions or any other hoof lesions (Table 4). Digital dermatitis and slurry heel also resulted in shorter stride length (NS) than cows with no lesions. There was a tendency for cows with sole ulcers to have a shorter tracking distance (p=0.09) than cows with no lesions (-0.08 vs. 0.00m, respectively). Mean head position was lower for cows with sole ulcers than those with no lesions or any other lesions although this did not reach significance. Cows with sole ulcers had significantly higher locomotion score (2.9) than cows with no lesions (7.7). This means that 6 of the 7 of the cows suffering from sole ulcers (86 %) were scored as lame (LS-3). However 3 of the cows (23 %) with no detected lesions were LS-3. Cows with haemorrhage had higher locomotion scores than cows with digital dermatitis, slurry heel and no lesions

Table 4: Effect of type of lesion on stride characteristics, production and head position of dairy cattle

	None n=13	SU n = 7	SH n = 19	DD n = 8	SLH n = 5	s.e.m	Signific-ance
Hind stride length (m)	1.71^{a}	1.44^{b}	1.67^{a}	1.58^{a}	1.54^{a}	0.190	0.03
Tracking (m)	0.00	-0.08	-0.02	-0.02	0.02	0.065	0.09
Stride duration (s)	1.18	1.18	1.23	1.10	1.22	0.396	0.95
Hoof speed (m/s)	1.69	1.26	1.56	1.54	1.38	0.651	0.68
Head position (m)	0.76	0.69	0.74	0.73	0.73	0.094	0.69
Max fetlock height (m) difference	0.08^{ab}	0.08^{ab}	0.08^{ab}	0.07^{a}	0.12^{b}	0.027	0.04
Max hock height difference	0.07^{ab}	0.08^{ac}	0.09^{b}	0.09^{b}	0.14^{b}	0.035	0.006
Spine length walking (m)	1.33	1.32	1.33	1.34	1.34	0.08	0.99
Thorasic spine length (m)	0.46	0.49	0.46	0.48	0.44	0.05	0.46
Lumbar spine length (m)	0.53	0.50	0.53	0.55	0.58	0.07	0.42
Spine length difference (m)	-0.02^{ab}	-0.08^{a}	0.01^{b}	-0.02^{ab}	0.00^{ab}	0.03	0.02

^{abc} different superscripts indicate significant differences between means within rows $p<0.05$
*None = no lesion, SU = sole ulcer, SH = sole haemorrhage, DD = digital dermatitis, SLH = slurry heel

Also in this study the spine length was measured when the cows were standing and then when they were walking. There was no significant difference in "Spine Length Walking" in relation to lesion type. However, this measurement does not take into account the different individual measurements of the cows. Although there were no statistical differences in back length standing with relation to lesion group. Spine length difference was calculated as the difference between the cows standing and walking in terms of back length. In the case of cows with sole haemorrhage back length actually increased when walking which may indicate these cows where "dipping" the spine although this effect was very small. There was a significant difference between cows with sole ulcers and those with sole haemorrhage, the cows with ulcers shortened the back by an average of 8cm when walking this may indicate they were arching the spine even though there was no difference in the marker height in the centre of the spine (L1). One limitation of this measurement was that it did not assess any arching of the spine when the animal was standing square.

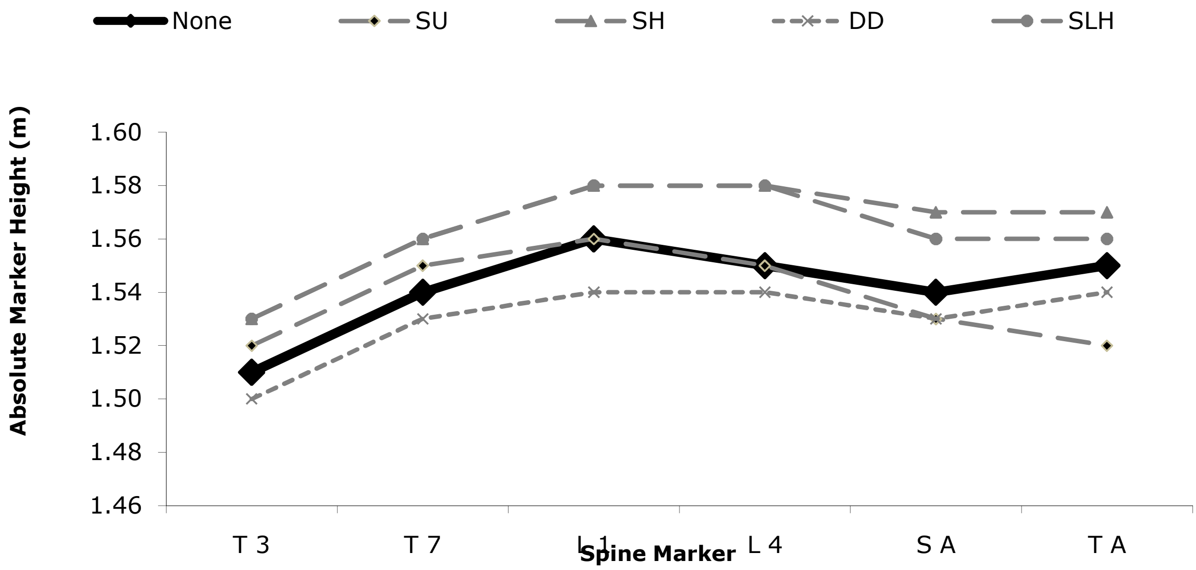

Figure 1: Effect of foot lesion on spine marker height while walking (None = no lesion, SU = sole ulcer, SH = sole haemorrhage, DD = digital dermatitis, SLH = slurry heel

There was no relationship between hoof lesions and the height of the spine markers (Figure 1). The cows with sole ulcers were numerically lower at the tail-head (TA) than cows with no lesions or the other lesions.

Lame cows (LS-3) in the aforementioned study had shorter fore stride length than LS-1 cows (0.26m shorter), as was the hind stride (0.25m shorter). This effect was also repeated in a second study; with the lame cows having shorter stride (0.17m and 0.15m shorter for fore and hind stride, respectively). The differences in stride length were smaller in the second study, this was likely to be due to the fact that these cows had slightly shorter stride lengths overall. This may be an environmental effect due to housing used for cows in study in study 1 had solid concrete walkways versus slatted concrete walkways in housing of cows in study 2 as the cows in both studies had similar wither heights (1.43m vs. 1.45m for study 1 and 2, respectively). The relationship between locomotion score and stride length was not seen in a third study. This study had few lame cows; this was due to the fact that the cows were locomotion scored weekly as part of an on-going study and therefore would receive functional trimming very quickly if they were recorded as lame. The cows studied in study 3 had much longer stride lengths than those seen in either of the preceding studies. These cows were again similar in wither height but they differed considerably from the other experimental cows in that they had been housed continuously from the birth of their first calf, some of these cows could have been housed for up to 6 years although most cows had only been housed continuously for around 2 years. These cows have access to an outside exercise area but may show some permanent gait adaptations, other studies have shown cows housed in cubicles for over two years were shown to have less flexation in their joints (20) the lameness status of these cows was not available. Environment can influence stride length with cows taking longer strides when walking in deep slurry (42) and on surfaces with larger aggregate (43). However, no attempt was made to comparatively evaluate the walking surfaces on the three farms used in the present studies. There may have been differences; however, the lame and non-lame cows are likely to behave the same on each surface.

Tracking distance changes in relation to locomotion score proved most repeatable across the 3 studies involving gait analysis. In all three experiments lame cows tended to have more negative tracking distance. This helps to validate the inclusion of tracking distance in subjective locomotion scoring systems. Particularly as tracking up has high intra and inter-observer agreement when assessed separately from other gait attributes in locomotion scoring systems (11,35). Cows with sole ulcers (12) and those which were moderately lame (46) have also been shown to have negative tracking in agreement with the findings in these studies.

Cows with sole ulcers (SU) had shorter stride length, negative tracking distance, longer stride duration in comparison with cows with no lesions. Cows with SU also had the lowest range of movement in the fetlock, the largest spine length difference indicating spine shortening through lengthening in the thoracic and shortening in the lumbar region of the spine region. Cows with SU also had greater stride length variation in the affected and contralateral limbs in a different study. These changes indicate that SU may be more painful than other lesions which were in agreement with work of Whay *et al.* (49) where cows with SU were more sensitive to pain. Gait adaptations related to SU were also seen in the studies of Flower and co-workers (12,13,14). The studies in this paper were the first to evaluate spine posture as part of the gait analysis process.

Cows with sole haemorrhage (SH) were similar to cows with no lesions in terms of kinematic measures of gait which was in agreement with Flower *et al.* (13). In a second study the relationship between the affected limb and other limbs were similar to those with SU and showed little variation across the limbs. This may indicate these as less painful lesions.

Digital dermatitis (DD) affected the gait of dairy cows in two separate studies. Cows with DD had shorter stride length than cows with no lesions, these cows also moved more slowly and had shorter stride duration compared with cows with no lesions in study one. In the second study, cows with DD had the shortest stride length on the affected limb with lower variation on the limbs. These findings may suggest the cows were showing gait adaptations relative to pain.

Cows which had slurry heel (SLH) had significantly different foot flight compared to cows with no lesions; they picked their feet up higher which was accompanied by shortening of stride length compared with cows with no lesion in one study. The converse pattern was seen in a second study with considerably longer stride length seen in the cows with SLH compared to no lesions. The reasons behind these differences are unclear and may warrant further research. The differences may be attributed to different herds and their management and environment.

Behaviour of lame cows

Cows with LS-3 spent significantly more time lying down ($p<0.05$) and less time standing up ($p<0.05$) than cows with LS-1. Cows with LS-3 spent approx. 2 hours longer ($p<0.05$) lying down than cows with LS-1 and LS-2 (Table 5).

Table 5: Effects of locomotion score on activity, production and lying behaviour of dairy cows.

Parameter	Locomotion Score 1 (n=16)	2 (n=21)	3 (n=22)	s.e.d.	Significance
Lying Down (h/day)	10.9[a]	11.1[a]	13.0[b]	0.74	0.010
Standing (h/day)	12.2[a]	12.0[a]	10.2[b]	0.69	0.008
Active (h/day)	0.9	0.9	0.8	0.08	NS
Lying Bouts per day	11.1	9.8	10.9	1.17	NS
Mean Duration of Lying Bout (min)	60.7	69.0	76.2	7.44	0.133
Minimum Duration Lying Bout (min)	6.4	6.9	8.4	2.22	NS
Maximum Duration Lying Bout (min)	151.4	168.9	190.9	18.41	0.112
Milk Yield (l /day)	37.3[a]	35.7[ab]	29.3[b]	3.19	0.001

[a,b] Indicate significant differences within rows $p<0.05$

The average duration of lying bouts numerically increased as locomotion score increased (p=0.133). Cows with LS-3 had 15.5 and 7.2 minute longer lying bouts than cows of LS-1 and LS-2, respectively. Maximum time spent lying down was slightly longer (p=0.112) for cows with LS-3 compared to cows with LS-1 and LS-2 although this did not reach significance. Cows with LS-3 spent a maximum of 40 minutes and 22 minutes longer lying down than cows with LS-1 and LS-2, respectively. The frequency of lying bouts was similar across locomotion score groups.
There was an effect of locomotion score on milk yield with cows with LS-3 producing 8 litres of milk per day (p=0.001) than non-lame cows (LS-1).

Diurnal behaviour of lame and non-lame cows is shown is Figure 2. Although LS-3 cows spent significantly more time lying down per day overall compared to LS-1 and LS-2 cows, lying behaviour was dependant on the time of day and management activity. Fewer (64 %) LS-3 cows were lying down between 12am and 3am than LS-1 and LS-2 (84 % and 75 % respectively). More LS-1 cows were recorded standing (lower proportion lying down) immediately after food was pushed up and immediately after the start of milking. Between 7am and 10am the majority of LS-3 cows were lying down (over 90 %) whereas fewer of the LS-1 and LS-2 cows were lying down. Most cows were standing up between 5am and 6am which coincided with morning milking and feeding.
Little data are available on the impact of lameness on the diurnal rhythm of lame dairy cattle and further research is needed to evaluate this relationship

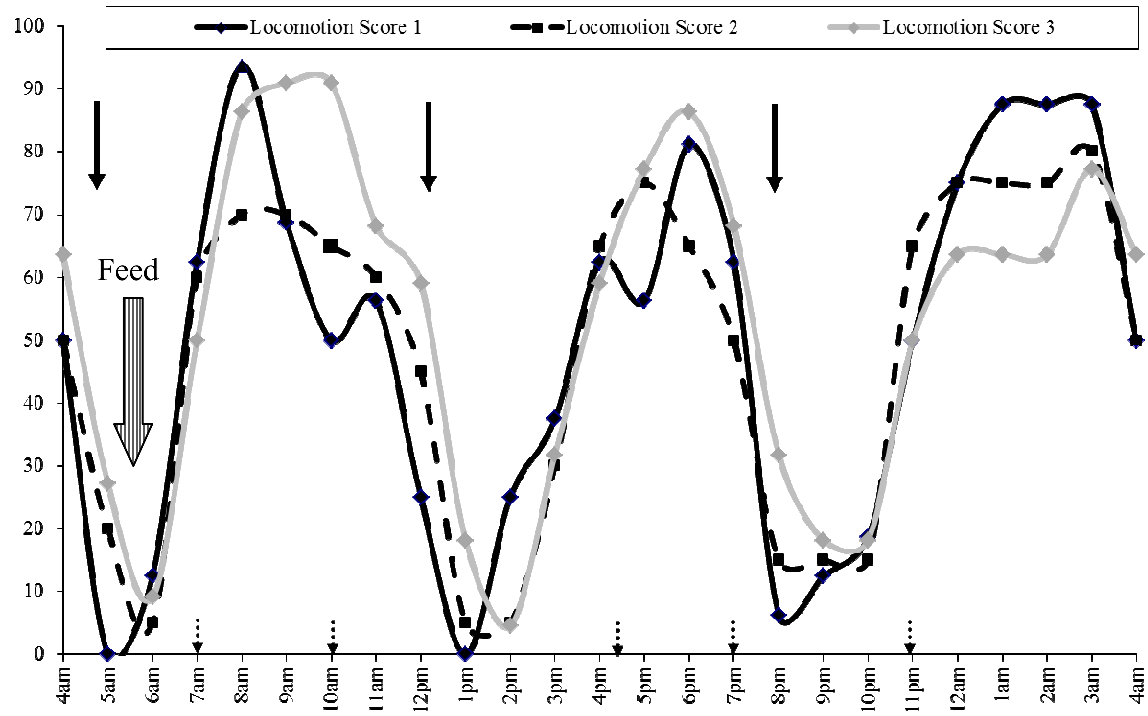

Figure 2: Percentage of cows observed to be lying down through a 24h period (mean of 4 days). Bold Arrows ( ) indicate time milking started. Dashed Arrows ( ) indicate approximate time feed was pushed up. Fresh feed is offered once daily at 5.30am (indicated by grey arrow).

Two studies undertaken showed that lame cows spent longer lying down than non-lame cows. On average the lame cows spend 2.1 hours/day longer lying down than non-lame cows in both demonstrating this was a repeatable effect. The magnitudes of the difference in lying times in the two studies were identical although the actual lying times were different. In one study the lame cows (LS-3) spent 11.1 hours/day lying down compared to 9 hours/day for the non-lame cows (LS-1); these cows were in early lactation (up to 12 weeks in milk) and therefore were experiencing a period of change and adaptation following parturition. These cows were also approaching peak milk yield and later peak feed intake which results in a reduction in time available for lying down. In the second study the lame cows (LS-3) spent 13.0 hours/day lying down in comparison to non-lame cows (LS-1) which spent 10.9 hours/day lying down. Cows used in study 2 were of various stages of lactation; however these cows were balanced to give a similar number of days in milk across the groups (approx. 25 weeks into lactation). Taken together these studies indicate lying time may increase with increasing number of days post-partum. Both studies have lying times in line with those reported in other studies of cattle housed in freestall cubicles in the UK (≈ 11 hours per day) for healthy cows (6,15). Most of the cows utilised in the present studies were milked three times daily and some experienced considerable enforced time standing up out of the cubicles while collected up for milking. This implies the cows then needed to fit their preferred lying time into the day along with the time required to spend feeding. Cows may choose lying over feeding when deprived of lying however, they do choose food if they were deprived of food only (without deprivation of lying as well) (23,26,32,34). Lying times in the present study were also consistent with those seen in high production American herds (7,8). Unfortunately in both the studies, the exact cause of lameness was not determined and as such lesion specific evaluation of lying behaviour is needed to assess the impact of different lesions on the time spent lying down and the frequency of lying bouts, particularly comparing infectious and non-infectious hoof disorders in order to refine management of lesions.

Lameness was also shown to impact on the patterns of lying bouts in the present studies. These changes in behaviour may imply that these cows were feeding (i.e. standing up) at quieter times, perhaps to avoid aggressive interactions. Some cows have been shown to modify their feeding times to avoid aggressive interactions in the study of Miller and Wood-Gush (1991). Similarly the main differences in lying times were seen in the evening between the lame and non-lame cows. These differences could be related to social rank of the lame animals.

CONCLUSIONS

Lame cows had shorter stride lengths both fore and hind, tended to have more negative tracking. Lame cows also had longer stride duration than non-lame cows. Lame cows also had a larger difference in spine length change between standing and walking which may indicate spine arching. Cows which were lame show significantly less variation in fore and hind stride length which may indicate that these cows are adopting the best compensatory movements to minimise pain. The main effects of hoof lesions on gait attributes were seen in the cows with sole ulcers. These cows had shorter stride length on the affected leg, showed a negative tracking distance and slower hoof speed. These cows also showed a slightly lower head position when the affected hoof was placed on the floor. The cows with sole ulcers also showed shortening on the spine when walking in comparison to the animal standing square. Cows with slurry heel showed different adaptations with the foot lifted higher accompanied with a shortening of stride length compared to healthy cows (no lesions).

Data from lying behaviour experiments show that lame cows spent significantly more time lying down per day overall compared to non-lame cows. Cows with lame cows tend to have longer mean and maximum lying bout length than non-lame cows. Lame cows also appear to modify their patterns of lying behaviour throughout the day when compared to non-lame cows.

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MILK LOSS, SORE HOCKS, FEEDING TIME AND FOOT TRIMMERS. RECENT LAMENESS RESEARCH AT NOTTINGHAM

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SUMMARY

Lameness in dairy cattle has been reported as a concern for welfare and economic reasons for over 20 years. Since that time the problem only appears to have worsened. Concerns are being expressed from across the industry and the issue has been highlighted in a number of recent high profile reports (1,2). The number of research groups involved in lameness work around the world is increasing; consequently the available published work is growing rapidly in this area. The following paper describes some of the research on lameness which has been conducted at Nottingham Veterinary School over the last three years.

MOBILITY, MILK YIELD AND MASTITIS

Seven dairy herds were selected on the basis of location (Midlands, UK) and having a minimum of 100 cows in milk at any time. It was confirmed that herd managers were committed to monthly milk recording through National Milk Records and had a willingness to participate in the study.

Assessment of mobility score for all milking cows on each farm was conducted at monthly intervals for 12 consecutive months between August 2008 and July 2009 by a single observer. Afternoon visits were timed to coincide with the monthly milk recording date +/- 10 days. All cows were observed walking on flat, non-slip concrete in a well lit location that was consistent on each farm. The DairyCo mobility score scale was used where zero coded "good mobility", one; "imperfect mobility", two; "impaired mobility", and three; "severely impaired mobility". Milk yield and somatic cell counts were obtained electronically from the farm monthly milk recording data. Data were analysed to account for the correlation of repeated measures of milk yield and somatic cell count within cow.

Results indicate that severe lameness (mobility score 3) was associated with a decrease in milk yield that commenced four months after the lameness was observed. A detailed description of these results has now been published (3). To aid application of the findings into a clinical context the results have been translated and simplified (Figure 1). The greatest reductions in milk yield are associated with the occurrence of severe lameness close to the time of calving, and its persistence. Until more is known about cost effective strategies to control lameness in different situation, these results emphasise the importance of prompt detection and treatment of lameness particularly in freshly calved cows.

Provisional analysis of the individual cow somatic cell count data from this study, indicates that, on some farms lame cows produce milk with a significantly lower cell count (4) demonstrating the complexity of the disease interactions which take place at a population level. Of interest is the finding which has also been demonstrated by other research that cows that were ever lame (mobility scores 2 and 3) tended to be higher yielding than those that were never lame i.e. lameness appears to a disease of high production. As a result any reduction in yield may not be tangible at the herd level; milk yield of lame cows is reduced towards that for "average" cows that are never lame.

Figure 1: The impact of monthly mobility score on the milk yield of dairy cows (5)

Estimated reduction in 305 day milk yield (Kg) for lame (score 2) and severely lame (score 3) cows, prompt effective treatment is assumed such that animals are not lame when reassessed after one month

DairyCo mobility score		2 (lame)	3 (severely lame)
Month of lactation when lameness case occurs	1	175	350
	2	150	250
	3	100	200
	4	50	100

Estimated reduction in 305 day milk yield (Kg) associated with chronic lameness for lame (score 2) and severely lame (score 3) cows

DairyCo mobility score		2 (lame)	3 (severely lame)
Number of months into lactation that lameness continues	1	175	350
	2	325	625
	3	425	800
	4	475	900
	5	500	1000

THE IMPACT OF LAMENESS ON FEEDING TIME

Previous studies, including the one described above have demonstrated that lameness is associated with a reduction in milk yield. It has been postulated that milk yield reduction is caused by a reduction in dry matter intake during the period that animals are lame. To investigate this relationship, a case–control study was conducted in a total confinement, robotically milked (Lely A3 robots), high yielding (~9950L/cow/annum) 210 cow Holstein herd. Animals were housed in groups of approximately 50, on cubicles bedded with mattresses; all floor surfaces were covered with rubber matting. Each group had continuous access to a total mixed ration at a single 29 metre feed face.

Case cows were mobility score 3 on a four point scale (DairyCo Mobility Score: 0 – Good mobility; 1 – Imperfect mobility; 2 – Impaired mobility; 3 – Severely impaired mobility); control cows were mobility score 0 or 1. Case / control pairs were matched by parity, days in milk, daily yield and body condition score. Case and control animals were identified with unique luminous glue-on markers for ease of identification. Video footage of the feed face was recorded for 24 hours periods using two high quality CCTV ceiling mounted cameras, with automatic infrared filming during periods of low light intensity and darkness. Following filming, recordings were reviewed and the number and duration of each feeding bout was recorded for all study animals.

Ten independent case / control pairs were followed during seven 24 hour recording periods. Results suggest that lame cows spent significantly less time (>60 minutes) eating each day compared to the sound controls. Whilst feeding bout length was similar between case and control cows, the average bout length was significantly lower in case animals.

The reduction in eating time demonstrated in this study is likely to be associated with a reduction in dry matter intake, although it remains possible that lame cows in whole or in part, mitigate the effects of reduced eating time by increasing the rate of dry matter intake. Further studies, which include the measurement of dry matter intake are required to further clarify the effects of this painful condition on feeding behaviour and milk yield.

THE ASSOCIATION BETWEEN HOCK LESIONS AND LAMENESS

The term "hock lesion" has been used to describe damaged and missing hair, hyperkeratosis, broken skin, scabs and swelling. Hock lesions are prevalent in housed dairy cattle across the UK, Europe and North America and have been positively associated with lameness in previous studies.

A cross-sectional study was conducted on 76 herds in the Midlands region of the UK during the housing period of 2007/8. From each herd a truly random sample of approximately 50 animals was assessed. Selected animals were scored for body condition, lameness, cleanliness, rising behaviour, and hock lesions. Hock lesions were scored on three separate four point scales for hair loss, ulceration and swelling. Additionally a detailed hock map was completed outlining the extent and location of partial hair loss, hair loss and ulceration. A detailed assessment was made of the housed environment and farm management practices. Data were analysed using univariable statistics and multilevel models. In separate models, hair loss (moderate or severe) ulceration (any level) and swelling (moderate or severe) were selected as the outcome variables; correlations within the data (hocks within cows within farms) were accounted for appropriately.

Data from lesions on 7382 hocks from 3691 animals in 76 herds were available for analysis. Lesions are prevalent at a number of locations on the hocks of UK dairy cows. Thirty eight percent of hocks demonstrated moderate or severe hair loss and seventeen percent demonstrated ulceration. A more detailed description of the location and extent of lesions will be available in the future (6).

A detailed description of the risk factors for all three lesion presentations will be available shortly (7). None of the 30 identified risk factors were common to all three lesion presentations. Mobility score, number of days of winter housing, mean milk yield, cubicle base material and herd size were common to both hair loss and ulceration. The cubicle bedding material was a common risk factor for both hair loss and swelling. A further 8, 5 and 11 risk factors were unique to hair loss, ulceration, and swelling respectively. Mobility score was positively correlated with both hairloss and ulceration i.e. animals with hock lesions were more likely to have an elevated mobility score and higher scores were associated with a greater degree of impaired locomotion.

The cause and effect in the relationship between mobility score and hock score has not previously been investigated and cannot be established through data collected in a cross-sectional study. That is the pain associated with hock lesions may make animals lame or alternatively lame cows may alter their behaviour (e.g. their lying behaviour) making the development of lesions more likely. Whilst at the current time it remains impossible to be sure of the direction of this association, the author is increasingly convinced that in some herds hock lesions are a primary condition and may be responsible for high levels of lameness. Intervention studies based on the risk factors identified in this and other studies are required to help reduce the severity and prevalence of this important condition.

DATA FROM FOOT TRIMMERS

DairyCo have recently produced standardised recording sheets to record the presence, location and severity of foot lesions identified during trimming by foot trimmers and farm staff. Working with the National Association of Cattle Foot Trimmers, DairyCo ask that one of the triplicate forms is returned to them so that data can be centralised. In a recent project, the first sheets returned to DairyCo by category 1 hoof trimmers were collated and analysed to identify the prevalence and severity of foot lesions seen during trimming.

5109 cows from 90 farms across the UK were trimmed between March and October 2010. Fifty six percent of all cows trimmed had at least one lesion. Sole bruising was the most commonly recorded lesion, followed by digital dermatitis, white line disease and sole ulceration.

The recording of lesions found during routine trimming is an essential step in first monitoring and then reducing the prevalence of lesions and lameness in UK dairy cows. Not only do farms benefit from having a detailed review of the types of lesion affecting their herd, but the national herd will benefit from the increased awareness of the types of lesions which cause lameness.

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Proceedings of the Cattle Lameness Conference (2011) Sutton Bonington, pp 39 - 47
Royal Veterinary College, The Dairy Group and University of Nottingham

IMPLEMENTING THE DAIRYCO HEALTHY FEET PROGRAMME

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SUMMARY

The DairyCo Healthy Feet Programme is due to be launched to dairy farmers (DairyCo levy payers) in September 2011. It has been designed to help dairy farmers reduce lameness through improved management of cows and people. The programme builds on the widely respected work of the Healthy Feet Project, funded by the Tubney Charitable Trust and carried out at Bristol University Vet School, and has drawn influences from other lameness reduction programmes worldwide. It has been developed in consultation with vets in practice and foot trimmers, as well as local and international lameness experts.

The programme is a step-wise approach which will assist any dairy farmer to make important progress towards diagnosing the problems, devising an action plan, and developing skills. Trained providers (mainly farm vets) facilitate the whole process and act as one-to-one advisers, or "**mobility mentors**". It is supported by various resources to ensure that the correct and relevant information is always to hand, and to encourage successful participation by farmers, vets, foot trimmers and advisers. The aim is to give farmers the confidence and knowledge to make the necessary changes to reduce lameness and improve their businesses.

This paper outlines the programme and describes its implementation on some pilot farms.

INTRODUCTION

The DairyCo programme began with the global wanderings of two Nuffield Scholars (Nuffield Farming Scholarship Trust). The first was Jo Speed, a DairyCo extension officer, who in 2008 was awarded a travel scholarship to study worldwide strategies for lameness prevention in dairy cows (8). Jo noted that unlike for example, mastitis control, with the 5-point mastitis plan, there is no system in place in the dairy industry that allows farmers to identify key areas for lameness control and develop an action plan. Lameness advice is often commercially driven (for example by manufacturers of footbathing solutions, minerals or antibiotics) and fragmented. It rarely allows farmers to appraise their system to see not only which lameness problems they are dealing with, but how to prevent them in the future.

Jo also discovered that programmes did exist globally, but that they were either research programmes (e.g. The Tubney Project, UK), commercial programmes (e.g. First Step™, Zinpro corporation, USA), or so specific to another country (e.g. Healthy Hoof Programme, DairyNZ, New Zealand) that they were not directly applicable on a wide scale to help UK dairy farmers.

In 2009, the author was also awarded a Nuffield Scholarship, in this case to study the role of the vet in knowledge transfer in the dairy industry (1). The author's interest in cows' feet naturally led to examining different approaches to influencing lameness reduction, as an example. One of the conclusions of the study was that pre-established, nationally co-ordinated programmes with support materials, training in delivery, and a wider marketing campaign to farmers can help vets to be become more effective communicators and advisers, to the benefit of their farm clients. The Healthy Hoof

Programme, co-ordinated by DairyNZ in New Zealand, is a good example of one such "product".

Meanwhile, closer to home, the excellent and extensive research carried out on lameness control as part of the Tubney funded Healthy Feet Project was coming to a close. Gratifyingly, the Bristol team demonstrated that farmers can indeed be influenced to make changes which reduce lameness (2, 6). This was achieved using a combination of raised awareness (for example herd mobility scoring), education, facilitation techniques and something called "social marketing" (for example, creating a "club" feel for participating farmers) (4, 5, 6).

The challenge, therefore, was to take the best parts of all the available programmes to create a product which:

1. works
2. farmers are keen to buy
3. vets (or other advisers) are keen to sell
4. has nationwide recognition and relevance throughout the UK

THE DAIRYCO HEALTHY FEET PROGRAMME IN CONTEXT

The result is the DairyCo Healthy Feet Programme. This is a new programme, with its own branding and identity, albeit with obvious similarities to the look and feel of the Tubney Healthy Feet Project, the experience from which it hopes to capitalise on. The sharp observer will also detect similarities with the New Zealand Healthy Hoof Programme, and some influence from USA's "First Step™", and the Dutch "Hoof Signals" (3).

In addition, the programme integrally incorporates regular independent herd mobility scoring, building on the valuable work (and materials) previously provided by DairyCo. In fact, if ever there was a logical starting place for the development of the programme, it would probably be the previous promotion of the DairyCo mobility score system within the dairy industry, which has not only raised awareness of lameness but provided us with a widely understood and practical basis for measuring lameness.

If measuring and detecting lameness (using mobility scoring) is considered the start, the next building block required nationally is probably better recognition and understanding of the different lesions causing foot lameness in the UK. To this end, DairyCo are distributing a lesion picture card ahead of the full programme launch.

Whilst the programme in its wider context includes such support materials and "tools", which can be used widely by the existing DairyCo extension officers and dairy farmers everywhere, this paper describes the delivery of the one-to-one aspect of the programme. For farmers to achieve significant reductions in lameness, it is envisaged that a tailored programme will be delivered to individual farms by trained mentors.

THE FOUR SUCCESS FACTORS FOR HEALTHY FEET

At the core of the programme are four success factors for healthy feet:

1. Low infection pressure
2. Good horn quality and hoof shape
3. Low forces on the feet (good cow comfort and good cow flow)
4. Early detection and prompt, effective treatment of lame cows

These provide a framework around which a lameness reduction plan can be agreed.

OVERVIEW

WHAT is the HFP? 1. A trusted and trialled approach to lameness reduction 2. Targeted assistance using external help (mobility mentors) 3. An array of resources to increase understanding and knowledge (mobility toolkit) 4. A systematic approach tailored to individual farms (lameness map and mobility contract)	**WHY** use the HFP? 1. to reduce the number of lame cows (severe, chronic or new) that farmers experience 2. lame cows cost farmers money and time and reduce work enjoyment 3. The HFP is a "package" which is easier to market than a less well defined approach 4. reducing new lame cases rather than dealing with already lame cows is a more intelligent (and valuable) use of veterinary input 5. lame cows are in pain and we don't like ourselves or others to see them that way
HOW does the HFP work? 1. It increases skills and knowledge so the whole farm team knows what to do to reduce lameness 2. It uses trained facilitators (mobility mentors) to guide the process 3. It brings the farm team together in a structured way to implement the necessary changes 4. It provides a framework to measure lameness, monitor progress and motivate all staff	**WHAT IF** I don't think it is for us? 1. You may feel confident you already have a planned approach to lameness control. How sure are you and how well are you able to market and implement it? 2. You may feel you have little to gain by becoming involved in lameness reduction. This work is rewarding and yields huge cost benefits to farm businesses, which has proven value. 3. You may feel this is for large herds only. It is for all herds. 4. You may be concerned about your ability to deliver and effectively charge for the HFP. The training programme of mobility mentors includes skills development to improve the chances of successful implementation on farms.

THE ONE-TO-ONE PROGRAMME

Once a farm has enrolled for the programme, the mobility mentor arranges for an initial **independent whole herd mobility score** to establish a first reference point for future comparison. Then a step-wise approach is taken to develop understanding and facilitate the farm team to decide their action plan:

Step One: Training, skills review and diagnosis.

The mobility mentor visits the farm and, working alongside the herdsperson, trims and assesses a proportion of cows' feet. During this visit, the mentor discusses how different diseases arise, and reviews the foot-trimming process, and what the conditions are that the farmer is seeing. Veterinary mentors assess the current effectiveness of any trimming and treatments which are carried out, and provide limited skills training. Some support for staff is provided through a variety of resources in a "**Mobility Toolkit**", including a **Hoof Care Field Guide** and a **Lesion Picture Card**. Where records of lesion types are available, they are used to devise a "**Lameness Map**": a simple graphical representation of the relative incidences of the most common lesions. The likely costs of lameness for the farm are reviewed. The visit is budgeted to take around three to four hours.

Step Two: Full farm risk assessment.

The mobility mentor carries out a thorough assessment of the farm and management with respect to lameness. This visit is budgeted to take around three hours, part of which is during milking time. The mentor goes everywhere the cows go, works with a check list alongside the farmer/ herdsperson and asks plenty of questions!

Step Three: Action plan.

Following the first two visits, the mobility mentor is in a position to help the farm team understand where the pressure points on the farm are in relation to lameness. Solutions are discussed, and points of action agreed. The action plan centres on the four key success factors for healthy feet and how these relate to the farm's specific "lameness map". This facilitation process involves the whole farm team and includes further discussion on which measures are important for which types of lameness. The culmination of this step is the production of a "**Mobility Contract**" which is the agreed points of action. The visit is budgeted to take around one hour.

Additional visits may be necessary, for example to give training in mobility scoring, or to precisely devise a new foot bathing protocol.

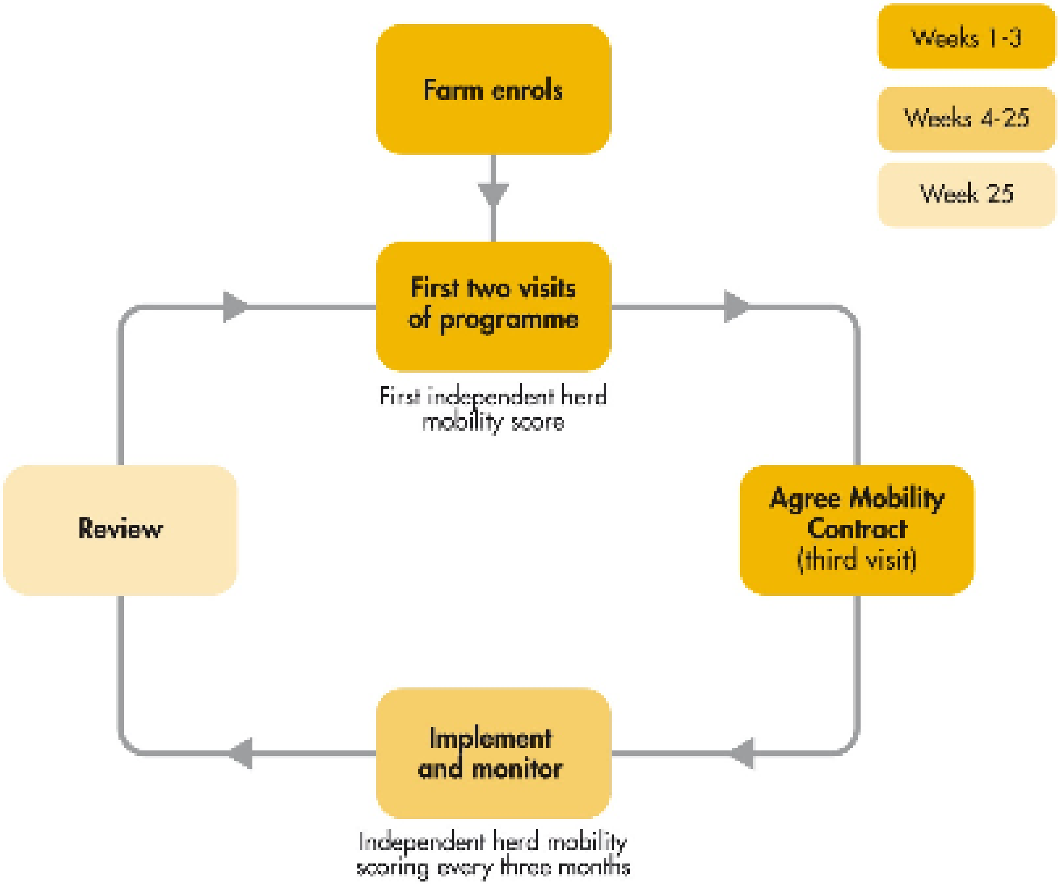
After the initial three steps, the programme is ongoing:

Step Four: Recording, monitoring, reviewing.

An action plan does not in itself bring less lameness. The farm team will use appropriate recording of all lame cows and lesion types found during routine foot checks. Mobility mentors ensure that the herd is mobility scored (preferably independently) on a 3-monthly basis to measure progress. This information is used to monitor improvements and re-draw the farm's "lameness map". Mobility mentors review how the action plan is being implemented by follow-ups at appropriate intervals. In any case, on-farm reviews at six-month intervals continue to check that the plan is still appropriate, and monitor skill levels on farm. New team members are updated, and if necessary steps one, two and three are taken again.

The review phase is probably the most important step for encouraging effective changes to take place. It is also the phase most vulnerable to being ignored, or carried out poorly (7).

TIME FRAME OF THE ONE-TO-ONE PROGRAMME



MENTORING

The success of the programme is dependent on the skills of the mobility mentor. Having excellent technical knowledge about lameness is only as important as the ability to facilitate effectively.

A thorough understanding of the biology of cows' hooves and a deep appreciation of dairy cow behaviour and management is a pre-requisite to become a mobility mentor. For this reason, most mentors will be vets with particular experience in dairy herd health (minimum of two years qualified), or NACFT (National Association of Cattle Foot Trimmers) hoof trimmers, holding the Category 1 accreditation (for a minimum of two years). Consultation with the industry is taking place in terms of recognition of other parties' skills which can be incorporated into the mentoring framework.

All mentors must complete a two-day training course, which will establish the minimum skills required to implement the programme, and a full appreciation of how the programme works.

All mentors will be registered and listed by DairyCo, and will commit to regular update training days to keep abreast of best practice in lameness reduction, and to learn from each other how to become more effective mentors.

<table>
<tr>
<td>WHAT is a mentor?
- A mentor is a trusted friend, counsellor or coach, usually a more experienced person
- Examples of famous mentors:
In sport, Bobby Charlton mentored David Beckham
In pop, Cheryl Cole mentors X-Factor contestants
In politics, Aristotle mentored Alexander the Great
In Star Wars, Obi-wan Kenobi mentored Luke Skywalker
In business, Freddie Laker mentored Richard Branson</td>
<td>WHY use a mentor?
To reduce lameness on farm, some changes will need to be made
Farmers will need guidance to work out which changes to make, and what is likely to be effective
Farmers will benefit from someone with more expertise and experience than them in reducing lameness</td>
</tr>
<tr>
<td>HOW does it work?
Mobility mentors are individuals who are trained to deliver the programme, and have expertise in lameness
Mentors use the processes in the one-to-one HFP to help the farm team decide their mobility contract
Mentors guide farmers so that the changes they make are likely to be effective, and demonstrate ways to measure and monitor this
Mentors give farmers back-up support to help them ensure the changes work</td>
<td>WHAT IF vets just want to diagnose the problems, and then advise the farmers what to do?
- Experience shows that this approach doesn’t work well. People do not respond to being “told” what to do – however “expert” the advice! Here are some reasons why:
People may not agree with the recommendations
People may not feel they are practical or relevant
People haven’t had the opportunity to think them through first
The whole of the farm team may not be on board
The chances are people will not make the changes!</td>
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</table>

RESULTS

1. Has it been possible to sell the programme to farmers?
2. Have there been tangible benefits?

1: Marketing and selling

The author has been helping to develop the programme over the last few years in practice, and has had the opportunity to try it out in various forms on several farms. All of the farms have had to pay for the time input of the programme, at £132/hour. Typically, this has been around 7 hours, working out at around £925, split over the course of three initial visits (two visits in its original incarnation). It certainly has been possible to sell the programme as a professional service, and feedback from farms on value for money has been positive in all cases. On one farm, part of the initial training visit was subsidised by a Regional Development Agency – there may be more scope for this type of support in different regions. Some farms initially asked for a training session (visit one), but have then gone on to ask for the remainder of the programme (development of an action plan).

Farms engaging in the programme have been a mixture of the author's regular clients, and (mainly) farms referred internally from other vets within the practice. Without regular mobility scoring, it has been hard to maintain the ongoing nature of the programme on some of the farms, with only *ad-hoc* reviews and refinements to the action plan. More recent incarnations of the programme have addressed this problem which has been to the satisfaction of the farmers involved.

To help with the delivery of the programme in its current form (with ongoing independent mobility scoring), a mobility scoring service is now offered by the practice at 25p/cow (minimum £25), which is done by a member of the practice support staff. It is envisaged that this service will in fact develop more opportunities for delivering the programme in its own right.

The price of the programme will be a decision for each individual participating practice/ mentor, and will depend on factors such as the size of the farm and time involved (anticipated around £1000). As the programme is ongoing, it is envisaged that a more suitable way of charging for it may be by a monthly contract fee, to include the initial time input (which is the main cost), regular mobility scoring, and regular reviews (e.g. £100/month).

During the development phase, the author's vet practice has not produced any marketing material in order to help sell the service to its clients. Marketing has been by word of mouth alone (mainly other vets' recommendations). Having support material from DairyCo, such as farmer leaflets explaining the programme, "prompts" such as stickers and a "mobility toolkit" and a recognised brand, ought to make the programme easier to market and use.

2: Feedback

The benefits experienced by each farm have been varied and not always easy to quantify. Initially, without regular mobility scoring, measuring progress was unreliable. More recent farms where the programme has been piloted have not yet had long enough to demonstrate improvements in mobility scores. Several of the farms have experienced changes in personnel since the programme was initiated, and this has inevitably led to set-backs.

Never the less, feedback has been positive on all farms, with the following aspects of the programme being particularly popular:

- Training in lesion recognition and aetiology
- The "workshop-style" approach to develop the mobility contract
- The inclusiveness of the programme: all staff involved. Several farms have commented positively about the team-building effect
- The use of the "four success factors" and the "lameness map" to simplify the complexities of different risk factors and explaining their relevance to the farm in question
- The Hoof-care Field Guide (once it became available)
- No written reports
- Practical contact details, for example of other farms who have successfully adopted some changes, or simply where to source certain equipment

Some examples of common changes which have occurred on farms include:

- Regular (weekly) mobility scoring to detect lame cows earlier
- New equipment (including cattle crushes) to help with quicker/easier treatment
- "Special needs" groups for lame cows to recover better (straw yards)
- Improved footbathing protocols

- Herdspeople attending hoof trimming training courses
- Improved treatment protocols (for example for digital dermatitis)
- Use of rubber matting on high traffic/ risk areas
- Increased bedding in cubicles to encourage longer lying times, and some cubicle modifications
- Altered yard-scraping frequency/ allowance of larger loafing areas
- Better attention to cow flow, particularly in the collection yard

THE CHALLENGES AHEAD

The success of the programme throughout a wider population is far from assured. The following challenges lie ahead:

1. Attracting and training mobility mentors: the model requires a good national distribution of willing and able mentors, who are happy to pay for their own training, and can see the benefits of delivering this programme. Ideally, those individuals who are already interested in cattle lameness will step forwards. This area of veterinary medicine has not historically been particularly popular (compared with, for example, fertility or mastitis work). Vets, in particular, may not recognise the value of the programme over and above their usual approach to lameness control, and this inertia must be overcome. In any event, it will take several years to train significant numbers of active mentors.
2. Vets need to embrace new (communication) skills required for successful mentorship: some individuals may enjoy the challenge and approach, whilst others will simply just "not get it". It might be surprising to discover which individuals have the right skills!
3. Veterinary businesses to successfully incorporate the programme in their commercial portfolio of services: this type of work is quite different to traditional reactionary clinical work done by a lot of vets. New ways of charging may be required by some practices, and vets' time organised to accommodate the work.
4. Attracting hoof trimmers to become involved in the programme: although vets are envisaged to be the main providers, some hoof trimmers could have the potential to be excellent mentors, but they, too, must be able to exploit the commercial possibilities of the programme.
5. Attracting farmers to see the value in the programme and encouraging them to pay for this type of veterinary input. This type of service will be very different to how the majority of farmers probably view their veterinary input (although this is arguably changing quite rapidly). It is probable that there will be a "slow build". The DairyCo Mastitis Plan has set a precedent which might be beneficial.
6. Quality control of mentors: bad experiences by farmers could damage the reputation of the programme immensely. Equally, bad experiences by mentors could damage the reputation amongst vets.

Despite these (not inconsiderable!) challenges, the author remains optimistic. The potential rewards at the end of the rainbow are too large to ignore: less lameness, happier, healthier cows, more profitable milk production and better job satisfaction.

ACKNOWLEDGEMENTS

Many people have been involved in the development of this truly collaborative programme. The Nuffield Farming Scholarships Trust and sponsors, The Trehane Trust, provided the author with the opportunity to learn so much from others around the world. In particular, thanks to Neil Chesterton (Healthy Hoof Programme, New Zealand), Nigel Cook (Wisconsin University, USA, co-developer of First Step™) and Jan Hulsen (Vetvice, The Netherlands; author of Hoof Signals and developer of "the four success factors").

Nick Bell, UK's own lameness guru, has been a constant bouncer of ideas and instrumental to the development of the programme, as have Jo Speed and Kate Cross from DairyCo, and Andrew Tyler, secretary of the National Association of Cattle Foot Trimmers. George Fisher, in his previous role as Head of Knowledge Transfer at DairyCo, was the instigator and deserves particular thanks for his faith in the concept of the programme from the outset.

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NOTES

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TOWARDS AUTOMATIC LAMENESS DETECTION USING 3D MOTION SENSORS

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INTRODUCTION

It has been shown in a number of studies that the activity patterns of cows can change as a result of lameness. In particular, an increase in lying time has been reported [1,2]. Conversely, insufficient lying time (for instance, due to a lack of cubicle space) is known to be one of the main causes of lameness.

The objective of this study was to evaluate the potential of detecting lameness based on activity patterns as measured by the 3-axis accelerometer IceQube® sensor device, attached to the rear leg of the cow.

In particular, the aims were to:
(1) Quantify the "average" effect of lameness in a specific herd, in terms of the activity measures of the IceQube®
(2) Look at changes in the activity measures in the lead up to, and following individual cases of lameness

METHODS

The trials were carried out at a commercial dairy farm in the south west of Scotland, and involved 163 loose-housed Holstein cows, the period of observation starting in February 2010 and lasting three months. During this time, a total of 855 manual mobility scores were recorded by The Dairy Group on 8 separate visits to the farm. Cows were scored according to a four-point scale (score 0 - healthy, score 3 - seriously lame). A histogram of the scores is shown in Figure 1.

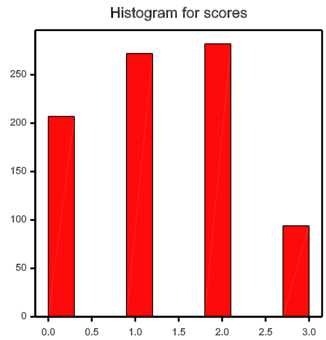

Figure 1: Manual Scores

Each cow was equipped with an early production IceQube® device, a new version of the IceTag sensor, the latter having been widely used and validated by animal scientists worldwide since 2008 (see e.g. [3]).

IceQube® devices record the parameters of 3-D Motion Index (MI), step count (which are summed over 15min periods) and lying/standing transitions. MI measures the overall acceleration of the tagged leg. Motion data is downloaded automatically and wirelessly onto a server whenever the tagged animal passes a trigger antenna at the exit of the milking parlour.

The data recorded here was summarised by day and analysed using a general linear model. In this model, the IceQube® activity data was taken as the response variable and the following qualitative factors were included as explanatory variables: cow no., oestrus (whether the cow was in heat on the day of scoring), manual mobility score and day of scoring.

RESULTS

It was found that the mobility score is a significant factor when it comes to both the step count and the lying time of a cow (with levels of significance of $P<0.001$). Based on the cows in the experiment, a score 3 cow can be expected, on average, to take 10% fewer steps and to lie down for 1.5 hours longer per day than when healthy.

Moreover, out of 16 cases of non-permanent lameness in the study, 9 were accompanied by a significant rise in either lying time or in the ratio MI/step count or both. Figures 2-5 give examples of changes in activity corresponding to lameness. Notice that Cows 91 and 149 both appear to miss an oestrus peak (in step count) as a result of lameness.

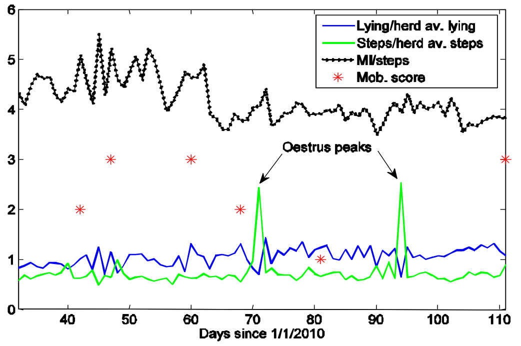

Figure 2: Activity of Cow 91
Unspecified lameness

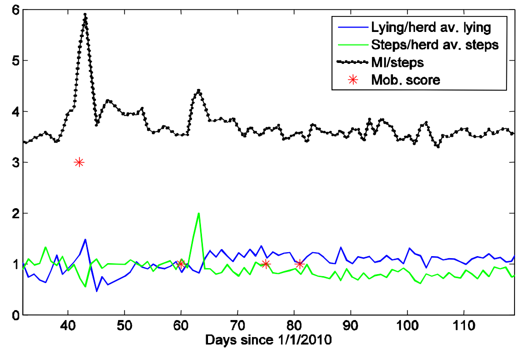

Figure 3: Activity of Cow 134
Mobility temporarily impaired

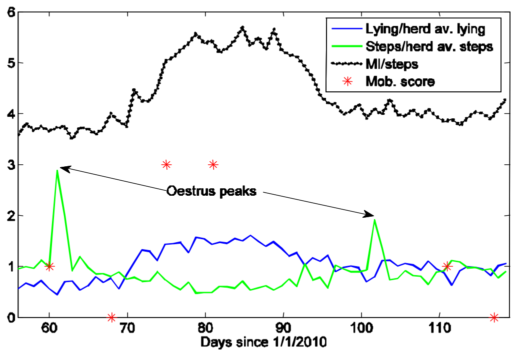

Figure 4: Activity of Cow 149
Treated for joint injury on day 77

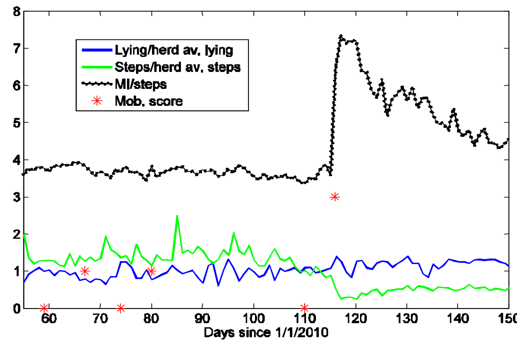

Figure 5: Activity of Cow 159
Split claw

CONCLUSION

The study confirms that lying behaviour can be indicative of lameness in cows. Furthermore, it shows that other activity metrics, such as the ratio of Motion Index to step count (a possible measure of the "effort" required per step) are also significant. By combining these measures, there is a good potential for automatic lameness detection using the IceQube®.

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FOOT DISORDERS IN DAIRY CATTLE: MODELLING IMPACT ON ECONOMICS AND ANIMAL WELFARE

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INTRODUCTION

Foot disorders in cows are an important health problem in current dairy farming with cubicle housing and concrete floors. Prevalence of foot disorders is high and does not decrease, despite extensive knowledge about its causes and remedies. Eighty percent of all the cows has at least one foot disorder and approximately one third becomes lame. This health problem has major implications for economics and animal welfare. In order to improve dairy cow foot health, dairy farmers have to take measures. More insight in the consequences of poor foot health can be a starting point for making improvements. The objective of this study is to estimate economic and welfare impact of different foot disorders, both clinical and subclinical, by using a modelling approach.

MATERIAL & METHODS

A dynamic stochastic model has been built to simulate foot disorders and to estimate the effects on economics and animal welfare, containing two parts. First, simulation of the occurrences of different foot disorders per cow per month, for a period of one year. This simulation gives the incidence and duration of the different foot disorders. Second, estimation of economic consequences and welfare impact. Input has been derived from literature and experts and applies to a standard situation in the Netherlands, assuming cubicle housing with a concrete floor, pasturing during summer, two foot trimming interventions per year and a herd consisting of mainly Holstein Friesian cows.
For each month a cow has a foot disorder, the model estimates economic consequences and welfare impact. Economic consequences are calculated using different cost factors: milk production losses, culling, prolonged calving interval, labour of dairy farmer, visit of foot trimmer, visit of veterinarian, treatment costs (e.g. antibiotics) and discarded milk. The welfare impact is assessed using the estimated pain of each foot disorder. Locomotion score (table 1) was used as indicator for the pain impact of each foot disorder in subclinical and clinical stage.

Table 1: Description of five categories of locomotion score used to assess the pain impact of the different foot disorders. Scores 1 and 2 represent subclinical foot disorders, scores 3, 4 and 5 represent clinical foot disorders, which cause lameness.

Locomotion score	Descriptive definition
1	Presence of a slightly asymmetric gait
2	Presence of an asymmetric gait
3	The cow clearly favored one or more limbs (moderately lame)
4	Severely lame
5	Extremely lame (non weight bearing lame)

RESULTS & DISCUSSION

In the model, which represents Dutch standards, foot disorders cost on average €53 per cow per year, with milk production losses and premature culling being the most important cost factors. Subclinical cases make up 32% of all costs and approximately 50% of the welfare impact. Digital dermatitis, with relatively high clinical incidence and long duration (table 2), has highest impact: almost 1/3 of total impact for both economics and welfare (tables 3 and 4). Sole haemorrhage and interdigital dermatitis/heel erosion, mainly subclinical with high prevalence, have a substantial impact on costs due to foot disorders (20% and 17% of total costs respectively) and on welfare (27% and 23% of total impact respectively). Interdigital phlegmon, the most painful foot disorder but with low incidence and short duration, is not very costly (10% of total costs) and has lowest welfare impact (0.5%) (tables 3 and 4). These estimations are on herd level. Looking at the individual cow, relatively painful foot disorders (like interdigital phlegmon) become more important, acknowledging individual suffering. The model built in this study can be used to model different circumstances and estimate the impact of foot disorders in varying circumstances.

Table 2: Incidence, cases/100 cows/year, and duration, in months, per case for the different foot disorders, by subclinical (SC) and clinical (C) cases in default situation (cubicle housing with concrete (slatted) floor, pasturing during summer (April through September), two foot trimming interventions per year (in April and October).

		IP[1]	IDHE[1]	DD[1]	SoH[1]	WLD[1]	SUL[1]	HYP[1]
Incidence (cases/100 cows/yr)	Subclinical	-	38	27	54	9	-	5
	Clinical	6	7	20	7	2	9	2
Duration (d), month	Subclinical	-	4.3	3.7	4.4	4.4	-	4.4
	Clinical	0.2	3.5	3.5	3.5	2.9	2.6	4.1

Table 3; Average costs per foot disorder per year on a farm with 65 cows.

Costs (€/yr)	IP[1]	IDHE[1]	DD[1]	SoH[1]	WLD[1]	SUL[1]	HYP[1]
Subclinical	-	313	191	473	83	-	48
Clinical	339	272	886	237	113	455	66

Table 4: Relative impact of the different foot disorders (subclinical and clinical) for the welfare impact on herd level (pain x duration x incidence).

Welfare impact (%)	IP[1]	IDHE[1]	DD[1]	SoH[1]	WLD[1]	SUL[1]	HYP[1]
Subclinical	-	14.8	11.5	21.0	3.3	-	3.2
Clinical	0.5	7.2	20.7	6.3	2.1	7.9	1.6

CONCLUSIONS

In Dutch dairy farming with cubicle housing and concrete floors, foot disorders are a major welfare problem with serious economic consequences. On average foot disorders cost €53 per cow per year. On herd level, subclinical foot disorders, which are the foot disorders not seen by dairy farmers, account for 50% of the total welfare impact and 32% of the total costs. On cow level, the welfare impact of the more painful, clinical foot disorders get more weight. Insight into these economic and welfare consequences of the different foot disorders, on herd and cow level, can support dairy farmers in deciding how to improve dairy cow foot health.

[1] IP = interdigital phlegmon, IDHE = interdigital dermatitis and heel erosion, DD = digital dermatitis, SoH = sole hemorrhage, WLD = white line disease, SUL = sole ulcer, HYP = interdigital hyperplasia.

FARMERS' MANAGEMENT STRATEGIES FOR DIGITAL DERMATITIS CONTROL IN ENGLAND AND WALES

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INTRODUCTION

Digital dermatitis (DD) is a painful disease currently considered to be the leading cause of infectious lameness in dairy cattle. However, little is known about the application and effectiveness of management strategies under commercial conditions. In practice, treatment is left to farmers' discretion, guided by their perception of the disease and their attitude towards its control.

METHOD

A telephone survey of 90 farmers who reported DD was carried out to establish how they perceived, detected, treated and prevented the disease. The survey was used to capture farmers' actual practices rather than eliciting their opinion on an ideal management approach. The percentage of farmers responding to each question was calculated and farmer views were analysed using discourse analysis.

RESULTS

Despite lameness (49%), reduced milk yield (37%) and pain (34%) being commonly reported implications of DD, only 10% of farmers described the disease as a 'major' problem. Fifty two percent of farmers described detecting lesions at an early stage of disease progression; however 42% of farmers reported not using the one topical antibiotic treatment licensed for DD. Despite equivocal research evidence for its efficacy, parenteral antibiotic treatment was common, with 51% of farmers reporting its use. While 41% of farmers perceived slurry removal as the most important control measure, 11% reported "a lack of knowledge and treatment solutions for DD".

CONCLUSION

Farmers used a wide variety of strategies while attempting to reduce the prevalence of DD; however few farmers perceived the disease as a major problem. This under-perceived importance of DD and the multitude of control approaches are causes for concern. Longitudinal on-farm intervention studies are urgently required to inform best practice.

Proceedings of the Cattle Lameness Conference (2011) Sutton Bonington, pp 55
Royal Veterinary College, The Dairy Group and University of Nottingham

AN ANALYSIS OF CLAW LESION RECORDS FROM 17 DAIRIES HOUSING COWS INDOORS

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INTRODUCTION

Claw lesion records are useful in monitoring the degree of lameness within dairy herds and, perhaps more importantly, provide keys to identifying underlying factors causing lameness. Currently, there is no database available to establish benchmarks for claw lesion diagnosis in dairy cattle.

OBJECTIVE

The objective of the current project was to merge claw lesion records from several dairy herds to establish a database to benchmark when and perhaps why claw lesions most likely occur. The final database consisted of 12 months of data from 17 dairies (12 freestall; 3 combination; 2 dirt lot) representing approximately 40,900 cows from herds ranging in size from 500 to 6,000 head in 9 states in the United States and 2 international herds located in the southern hemisphere. The database was partitioned and analyzed as two separate datasets: 1) herds recording only lame events (n=8) and 2) herds recording both lame and trim events (n=9). Data was analyzed using PROC FREQ (SAS v9.2) and significance determined using Chi-Square.

RESULTS

White line disease, sole ulcer, toe ulcer, digital dermatitis and foot rot comprised 93% and 40% (excluding routine trim with no lesion, 55%) of lesions for herds recording only lame events and lame and trim events, respectively. Ratio of infectious to non-infectious lesions decreased with increasing lactation number ($P \leq 0.01$) in both datasets. Digital dermatitis and foot rot were greatest in the first 60 DIM and differed across parity ($P \leq 0.01$). Non-infectious lesions were greatest following summer heat stress whereas infectious lesions were greatest during the coolest quarter of the year.

SIGNIFICANCE

These data indicate 1) distribution of non-infectious lesions follow a typical lactation curve and predominated the three months following summer heat stress and 2) infectious claw lesions predominate in early lactation and during cooler months of the year.

Proceedings of the Cattle Lameness Conference (2011) Sutton Bonington, pp 57 - 58
Royal Veterinary College, The Dairy Group and University of Nottingham

SOLE AND HEEL ULCERS – WHATS THE DIFFERENCE?

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ABSTRACT

There is little information about the aetiology, presentation and outcomes of dairy cows with heel ulcers. This study compares heel ulcers with sole ulcers on a UK dairy farm and analysis presentation, recovery and outcome for both types of lesion. Our findings indicate that heel ulcers differ significantly from sole ulcers with longer time for recovery and increased chance of amputation and/or removal from the herd in cows with heel ulcers.

BACKGROUND

In one study (1) of 1824 dairy cows across 30 UK Dairy farms a mean incidence rate of lameness of 0.32 per 1000 cow-days was reported to be as a result of claw horn lesions. Other authors (2, 3 & 4) quote sole ulcers as a cause of 15.9%, 16% and 31.5% of all reported lameness incidences respectively. While sole ulcers are reliably classified and their aetiology is widely understood, heel ulcers remain largely unidentified as a separate identity and their own aetiology less investigated.

Confusion over nomenclature when describing claw lesions potentially contributes to the lack of information on this subject. In this report a heel ulcer is described as having characteristics that set it apart from a typical sole ulcer (3 & 5) and other lesions involving the heel horn - it is a small haemorrhagic lesion in the caudal aspect of the sole shown as zone 6 in Fig 1. Paring of this lesion commonly reveals a defect in the sole horn which tracks back obliquely towards the heel corium.

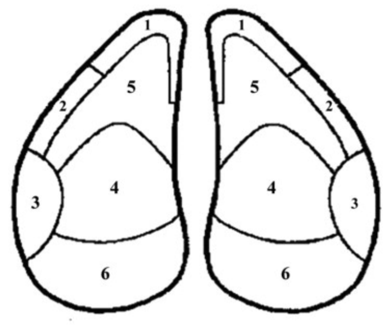

Figure 1. Claw diagram showing claw zones used in recording lameness-causing lesions. Adapted from Shearer et al. (2004).

In one study (5) 927 cows contributing to a total of 1104.6 cow years showed a mean incidence of 5.7 heel ulcers/100 cows/year and an incidence of 15.9 sole ulcers/100 cows/year. Another study (3) reported heel and sole ulcers incidence rates to be 0.11 and 0.23 per 1000 cow-days. In the same study, greater parity was associated with increased incidence rates for both heel ulcers and sole ulcers, and highest incidence rates for both types of ulcer were seen in mid lactation (61-150 DIM). Peer reviewed literature regarding the aetiology of heel ulcers is scant. However it has been reported (3) that thin soles were a significant risk factor for both sole and heel ulcers. There is limited published literature regarding differences in prognosis between heel and sole ulcers.

METHOD

Dairy cows suffering from heel ulcers or sole ulcers on several farms were observed and their lesions described and monitored. Dairy cows from one farm were selected for the study following diagnosis of lameness caused by a heel or sole ulcer. Parity, days in milk and foot affected were recorded in each case. Cows were re-examined weekly until sound. Date of initial presentation and final examination and outcome of treatment (ongoing lameness, recovered, amputation or cull) was recorded for each cow. Cows with missing entry or exit dates were excluded from the analysis. Association between exposure, parity and outcome was examined using Fisher's exact test. Time to recovery (days) by heel or sole ulcer was examined by t-test.

RESULTS

137 cows were eligible for analysis: 59 with heel ulcers and 78 with sole ulcers. The cows were assessed in the period from July 2008 until December 2009 with follow up in February 2011. Findings are summarised in the table below:

Observation	**Sole ulcers**	**Heel ulcers**
Limb distribution: Forelimb Hindlimb	 16 84	 10 90
Mean parity	1.7*	3.9*
Mean days in milk (range)	81 (1-302)	90 (1-479)
Mean days to recovery (range)	41.3* (14-399)	74.2* (21-497)
Outcome: Percentage with digit amputated Percentage no longer in herd after 12 months	 2.7* 7.1*	 16.9* 39.0*

* denotes significant difference (p >0 .05)

DISCUSSION AND CONCLUSION

Sole ulcers and heel ulcers differ significantly in their presentation, days to recovery and clinical outcome. Heel ulcers are more likely to affect older animals with a long time taken for recovery and more likely to result in digit amputation and/or their subsequent removal from the herd than sole ulcers. Ongoing studies will attempt to examine this trend in additional herds as well as investigate the pathology and histopathology of the lesions.

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ACKNOWLEDGEMENTS
The authors would like to acknowledge the work at Cambridge University of Rob Paton and Toby Floyd for their involvement in the initial study and also Fernando Constantinez for his ongoing work on pathological samples.

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COLLATING AND MONITORING FOOT HEALTH DATA IN A LARGE SOMERSET DAIRY HERD

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INTRODUCTION

An approach to monitoring foot health in a 600-cow Somerset dairy herd averaging 9000 litres on a 305-day adjusted lactation is described. The herd receives regular veterinary input via a weekly routine herd health visit, covering aspects of fertility management, herd monitoring, data analysis and discussion.

FOOT HEALTH DATA COLLATION AND CAPTURE

Cows treated as lame are recorded using an on-farm database (Interherd, Pan Livestock Services Ltd) and includes the cow identity, lesion identified and the date of treatment. In addition, the milking herd and transition cows are mobility scored every month by the herd's veterinary surgeon using the current DairyCo industry standard (a four-point scale where 0 = sound and 3 = severe lameness). The vet and the herd manager mobility score and body condition score at the same time, ensuring that wherever possible, the cow identity is captured correctly. Mobility scores are collated into an excel spreadsheet in a simple format to include score date, cow identity and score result.

ANALYSING FOOT HEALTH DATA

Data contained within the on-farm database are regularly analysed using the Total Vet software (QMMS/SUM-IT) and mobility scores merged into the database to match cows contained in the herd to cows observed and scored on a monthly basis. Cross-checking of the data can then be carried out to ensure the data integrity (i.e. the proportion of the herd scored at the latest mobility score date and the proportion of the herd that were missed) remains high.

INITIAL ASSESSMENT OF HERD TRENDS IN MOBILITY DATA

Analysis of the mobility score data is carried out using the Total Vet software. The software generates several mobility score reports and can be emailed directly to the farm team, consultant and other vets in the practice from within the software. Reports used include:

- A report of the proportion of the herd scored at the score date,
- An overview of the mobility score prevalence,
- An overview of the herd using cows present at BOTH the latest score dates, assessing the movement around the mobility score lameness threshold
    - Cows that were mobility score 0 or 1 last score and are mobility score 2 or 3 this score are labelled 'New Lame'
    - Cows that were mobility score 0 or 1 last score and remain mobility score 0 or 1 this score are labelled 'Sound'
    - Cows that were mobility score 2 or 2 last score and are mobility score 0 or 1 this score are labelled 'Cured'
    - Cows that were mobility score 2 or 3 last score and remain mobility score 2 or 3 this score are labelled 'Chronic'

Using this overview, cows can quickly be checked to see if any treatment has been carried out or if cows need to be scheduled for foot-trimming in the next few days.

LAMENESS ACTION LIST

Using the latest mobility score data, an 'action list' for the herd is also presented for use and reference. This lists all cows currently in the herd by foot health status and collates the latest mobility score, the three previous mobility scores, lactation details, lameness treatments and current mastitis information to aid management of individual cows. Current foot health status is described as chronic, new lame, lame, uncertain and sound and is dependent on the availability of regular mobility score data.

FURTHER ASSESSMENT AND MONITORING

The routine herd health visit after each mobility score session will include some time going over the results and analysis and allows more in-depth discussion of the data using Total Vet if required. This may include:

- The incidence rate of cows treated as lame (overall and by lesion type)
    - by month (allowing for seasonal patterns to be investigated)
    - by stage of lactation
    - by time since birth (allowing the treatment rate in heifers as they enter the adult herd to be investigated)
- The RATE at which previously sound cows become lame as measured by mobility score between score dates in the last 18 recordings
- The RATE at which previously lame cows become persistently lame (i.e. were observed to be score 2 or 3 at previous mobility score dates and remain chronically lame) between score dates in the last 18 recordings
- The proportion of HEIFERS moving into the 'new lame' category between the latest mobility score dates, having been present on both occasions

CONCLUSIONS

The Total Vet software allows for the rapid integration of mobility score data captured on farm and this data to be efficiently analysed and reported back. Reports can be emailed directly, allowing the veterinary advisor to distribute information to different members of the team quickly. Information is available for the individual cow in the form of action lists for treatment and for the herd in the form of rates and prevalence data to investigate and monitor disease trends and patterns as part of the advisors role in ongoing herd health.

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LAMENESS CONTROL IN DAIRY COWS FACILITATED BY THE USE OF HERDKEEPER

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Effective control of lameness in dairy cows on farms should be achieved by early identification of lame cows, with prompt and effective treatment. Mobility scoring has in recent years been heavily promoted (DairyCo) and in practice provides a good method of detecting lame cows, especially in large herds. However, recording and processing the large amount of data can be very time consuming and mobility scoring without subsequent action becomes an auditing exercise only.

Recording of lesions is often limited or absent on farms and if these are recorded there is frequent confusion over the diagnosis. It is most important to have common agreement on the description of the main lesions found and to be able to group these according to likely risk factors.

An ideal situation should be one in which cows are regularly mobility scored (every 2 to 4 weeks) for early detection of lameness and the mobility score (MS) 2 and 3 cows inspected and trimmed and treated appropriately. MS 3 cows should be examined as a matter of urgency and the authors would suggest that all score 2 cows are examined within 48 hrs. Lesion types found would be recorded and categorised by lameness type. Periodic review of these should allow the likely risk factors for the lameness to be investigated and appropriate action taken to reduce the number of new cases. This Handling this amount of data and tracking cows' progress ideally requires computerised records; Synergy Farm Health working in conjunction with Stellasoft have produced a software package called Herdkeeper that, combined with competent practical trimming skills, in the authors' opinions is able to meet all the requirements for good control of lameness. An inherent requirement is the close cooperation between farmer, vet and foot trimmer.

Both mobility data and foot trimming data is intricately linked in the database to allow both 'on-farm' analysis and cross reference of lameness records by foot trimmers as well as more in depth analysis of lameness records by the attending veterinary surgeon or consultant.

Key elements of the program include:

- Designed and tested by foot trimmers and vets with specific interest in lameness control
- Large ruggadised lap tops for easy manual entering of data on farm
- Portable blue tooth printers to allow reports and action lists to be printed and left on farm at time of visit.
- List function for recording identification of cows to facilitate use with herringbone parlours.
- Immediate analysis of mobility score data.
- Action list of cows requiring treatment automatically produced.
- Mobility scoring generates list of cows in foot trimming recording session.
- Full print out of all cows trimmed with appropriate treatments
- Highlights cows scored lame not presented for trimming
- Summarises causes of lameness from trimming session and categorises nature of lameness
- Action list left on farm following trimming session to highlight:
  - Cows for bandage removal
  - Cows to discuss further treatment with attending vet
  - Cows to refer to vet

In the authors' opinion 'Herdkeeper' is a vital tool for the overall recording and analysis of lameness levels on farm and its use should be considered by all those interested in managing lameness on farms. Furthermore, used in the correct manor, it encourages a team approach to lameness control.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the continued patience, support and help with the trialling of the project from Dave, Matt, Tim, Tom and Roy (the Synergy Paraprofessional Team) and also to Yvonne Critchell for her poster design.

Proceedings of the Cattle Lameness Conference (2011) Sutton Bonington, pp 63 - 64
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FOOTBATHING REGIMES FOR DIGITAL DERMATITIS - EFFECTIVENESS OF HYPOCHLORITE

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INTRODUCTION

Digital dermatitis (DD) has become a world-wide problem since it was first reported 30 years ago (1). Regular footbathing of cows with an effective antibacterial product is an essential part of DD prevention and control. Antibiotic and formalin footbath solutions are effective in reducing and/or controlling the problem, but neither can be recommended for use in footbaths. Copper sulphate is commonly used in footbaths because it is widely available and relatively easy to use, and has been found to be effective against DD when used on a regular basis (2). Nevertheless, concerns about the environmental impact of copper solutions mean that it is imperative to consider alternatives.

A cheap alternative footbath solution could involve the use of circulation cleaner from the milking parlour wash cycle, and evidence suggests that some farmers already use "parlour washings" (3). Hypochlorite, commonly known as bleach, is often used in the final rinse of the parlour wash cycle. This study aimed to investigate the effectiveness of a 2% hypochlorite solution used in a footbath in the treatment of digital dermatitis.

MATERIALS AND METHODS

Lactating cows from the experimental herd at the Agri-Food and Biosciences Institute (Hillsborough) were allocated to one of three treatment regimes over a 5 week period: 1) weekly footbaths with 5% copper sulphate (n=40), 2) weekly footbaths with 2% hypochlorite (n=39), or 3) no footbathing (control; n=39). The cows were balanced across treatments for a number of factors including milk yield, body weight and condition score. During the study period the cows walked through a water bath followed by the treatment footbath after milking on four consecutive occasions. Digital dermatitis was scored on the hind claws of all animals during milking on a weekly basis using a 5-point nominal scale (4): M0 - no DD lesions; M1 - early stage DD lesion, 0.5-2.0 cm; M2 - classical ulcerative stage DD lesion, >2 cm; M3 - healing stage DD lesion, covered by a scab; M4 - chronic stage DD lesion, characterised by dyskeratosis or proliferation of the surface. The effect of treatment on the proportion of cows in different DD lesion stages was analysed in Genstat 12 using General Estimating Equation (GEE) analysis with a binomial error distribution and an ante-dependence covariance structure of 1 between weeks. The number of transitions between the different DD lesion stages across the different time points (i.e. weeks) was also determined.

RESULTS

Figure 1 shows that by the second week of the study the 5% copper sulphate footbathing regime had already led to a reduction in the proportion of cows with M1 and/or M2 lesions on one or both of their hind legs. In contrast, the proportion of cows with M2 lesions actually increased by the second week of the study in the other two treatment groups.

Over the 5 week study period, the proportion of cows with M1 and/or M2 lesions declined significantly in the 5% copper sulphate treatment from 0.53 to 0.21 ($P<0.05$, SED=0.120). This proportion increased significantly in the control treatment from 0.39

to 0.65 (P<0.05, SED=0.120), and increased non-significantly in the 2% hypochlorite treatment from 0.45 to 0.62 (P>0.05).

In total, there were 888 transitions between the different DD lesion stages recorded during the study. The proportion of hind feet with DD lesions remaining absent (M0) was similar for all three treatment regimes (0.42, 0.39 and 0.38, respectively). The proportion of active DD lesions (M1 + M2) in the hind feet that did not improve (i.e. stayed the same or got worse) during the treatment study were 0.08, 0.35, and 0.31 for the 5% copper sulphate, 2% hypochlorite and "no footbathing" treatment regimes, respectively. The proportion of active DD lesions (M1 + M2) in the hind feet that improved (i.e. followed by M3 or M0 stage of DD lesion) for the 2% hypochlorite treatment regime was almost half that of the copper sulphate treatment and similar to that of the control treatment (0.07 vs. 0.13, respectively).

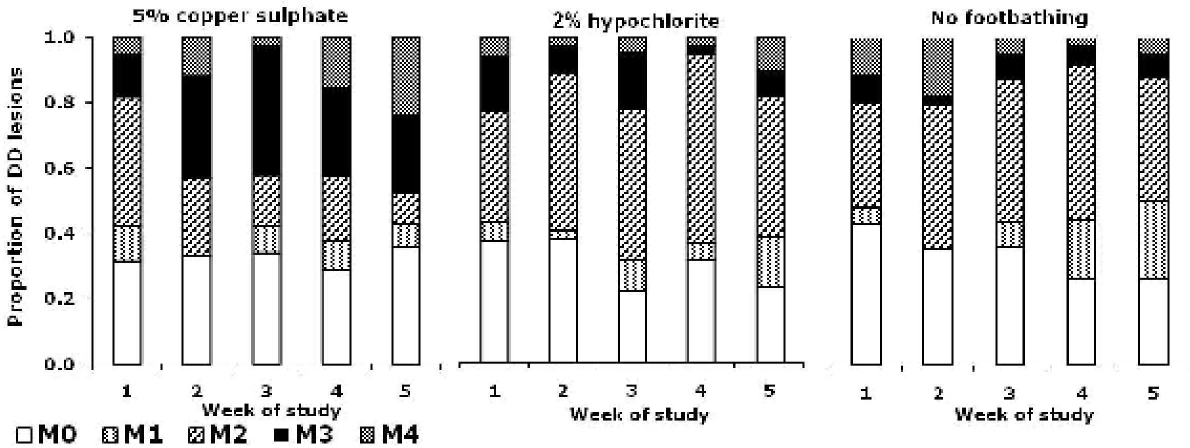

Figure 1: Proportions of the different digital dermatitis (DD) lesion stages (M0 to M4) observed over the study period for the 3 footbathing treatment groups.

CONCLUSIONS

The results of this study indicate that regular footbathing with a 2% hypochlorite solution is not effective in treating and controlling DD. Therefore caution should be applied when relying solely on hypochlorite parlour washings within a footbathing regime.

ACKNOWLEDGEMENTS

This project was funded by AgriSearch and DARDNI. The co-operation of the technicians and stockmen in the Dairy Unit was invaluable

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Proceedings of the Cattle Lameness Conference (2011) Sutton Bonington, pp 65 - 66
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USE OF HEALTHY HOOVES® TO REDUCE LAMENESS ON A UK DAIRY FARM

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INTRODUCTION

Lameness is highly prevalent dairy cattle and has significant economic and welfare implications (1). Approximately 20 to 25% of all cases of lameness worldwide are attributable to digital dermatitis (DD), and in the UK, approximately 70% of dairy farms are affected with DD (2). Digital dermatitis is a multifactorial disease defined as a circumscribed, erosive to papillomatous, intensely painful lesion that is often surrounded by a ridge of hyperkeratotic skin bearing hypertrophied hairs and is associated with lameness (4). In a review (3) of footbath formulations that are commonly used in the UK for treatment of digital dermatitis, it was found that, despite the array of substances used in footbaths, very few had been tested in controlled studies, and that their mode of use was subjective and efficacy unknown. The objective of the study was to evaluate the effectiveness of using Healthy Hooves® as a footbath solution, compared with normal farm practice of using a copper sulphate solution, on the incidence and severity of lameness in dairy cattle, and in particular on digital dermatitis.

METHODS

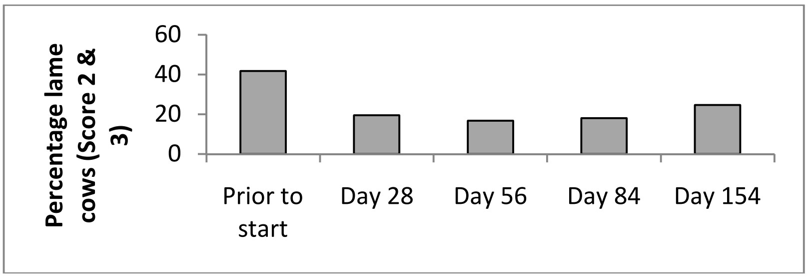
A total of 84 animals were used in the study. From the start of the study, each animal in the herd was footbathed on a twice-daily basis for ten consecutive milkings each week (Monday afternoon to Saturday morning inclusive). A longitudinally split footbath was used, with the control treatment (5% copper sulphate solution; CS) used in the left hand side of the footbath (i.e. each animal's front left and hind left feet were exposed to CS) and Healthy Hooves® (2% Healthy Hooves solution plus 2% copper sulphate; HH) used in the right hand side (i.e. each animal's front right and hind right feet were exposed to HH). The allocation of treatment solution to each side of the footbath was randomly decided by the toss of a coin. The CS solution was changed daily, whilst the HH solution was changed three times per week. The preparation and changing of all footbath solutions was performed by study staff for the duration of the study. The study commenced on 01SEP10 (Day 0) and continued for a 12-week period, until 25NOV10 (Day 84).

Prior to the start of the study, each animal was mobility scored and had all four feet lifted, trimmed where appropriate, and scored for the presence and severity of digital dermatitis, to enable baseline data to be collected. Mobility scoring was then performed every 4 weeks until the end of the study (i.e. on Day 28, Day 56 and Day 84). An additional mobility score was collected 10 weeks after the completion of the study. An assessment of the presence and severity of digital dermatitis was also made on Day 84.
During the mobility scoring assessment, each cow was observed walking on a level concrete surface, and scored on a scale of 0 – 3, using the recognised DairyCo lameness scale. For cows scored 2 or 3, the lame leg was also recorded. During the digital dermatitis assessment, and where digital dermatitis was present, this was scored as mild (Score 1), moderate (Score 2) or severe (Score 3).

RESULTS

The results of the mobility scoring clearly show a reduction in the number of lame cows (i.e. Scores 2 & 3) by Day 28 of the study, and that this reduction was maintained for the duration of the study. Interestingly, 10 weeks after the completion of the study, the percentage of lame cows in the herd had increased from 18.1% to 24.7%.

Figure 1.
Percentage of lame cows (Score 2 & 3) during the study



Prior to the start of the study, 28 (33.3%) of enrolled animals had DD affecting at least one foot. DD lesions were recorded on a total of 35 feet, with 13 of these being on the right and 22 on the left. By Day 84, only 3 animals (3.6%) had persistent DD lesions.

Table 1.
Incidence and severity of DD lesions

	Prior to Start		**Day 84**	
	Left feet	Right feet	Left feet	Right feet
Mild (Score 1)	8	3	2	2
Moderate (Score 2)	8	4	0	0
Severe (Score 3)	6	6	0	0
No. cases scored 1 - 3	22	13	2	2

The effects of each Test Article on reducing the severity of digital dermatitis were analysed, but were found not to be significantly different from one another (Mann-Whitney test. $P > 0.05$), as each treatment virtually eliminated digital dermatitis.

SUMMARY

This study clearly demonstrated that footbathing with Healthy Hooves® controlled DD in the study animals as effectively as using 5% copper sulphate, whilst using significantly less copper sulphate. The amount of copper sulphate used in the CS group was 300kg (5kg per 100 litres, changed five times per week for 12 weeks), compared with 72kg in the HH group (2kg per 100 litres, changed three times per week for 12 weeks), representing a 76% reduction in the amount of copper sulphate used. There is growing concern that the use of copper sulphate footbath solutions contributes to the accumulation of copper on soil, as footbath water is typically discarded into the manure lagoon and therefore spread onto land.

This study provides further evidence that routine footbathing, coupled with a regular foot care programme, can control digital dermatitis and reduce the incidence of lameness in dairy cattle.

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NOTES