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## The Effect of Environmental Factors on the Occurrence of Hoof Diseases in Irish Dairy Cattle Herds


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# 1. Introduction

Dairy farming is an integral part of the agricultural industry in Ireland. At present there are 19,000 dairy farms in the country. In comparison to the EU, the dairy farms in Ireland are of a smaller size averaging out at an approximate size of 150 cattle per herd (Euro group consulting alliance). Ireland has a suitable climate for utilising a grazing system for feeding for part of the year and housing when the grass growth rate ceases. Maintaining good herd health and welfare is of utmost importance in order to maximise the output from these animals.

Hoof diseases and lameness are becoming more evident due to the increase in intensity of farming. When an animal presents with hoof disease is it not only this part of the cow that suffers as her general well being is affected. Good feed intake is required for optimum milk production, as hoof diseases can cause considerate pain to the animal in walking, laying down and rising, this will ultimately result in a decreased feed intake. Therefore any arising hoof diseases will have a knock on effect on the production of the cow. If lameness from either injury or hoof problems is widespread throughout a herd it will automatically affect the economy of the herd as a whole, possibly even jeopardising the future existence of the herd.

The most important factors for cow health are those that allow the maintenance of natural behaviour in her daily life. These include resting, eating, ruminating and socialising and in order for the cow to be willing to carry out these activities she has to be able to lie down and rise. As the hoof is the part of the anatomy of the cow that has to impact with the surface in the environment and the hooves are the weight bearing surface of the cow any disturbance to the regular conformation of this may result in many problems for the animal. If the cow is less willing to walk, she is less willing to feed.

With good stockmanship and hoof maintenance, the majority of hoof diseases can be prevented or minimised resulting in a better overall performance of the herd as long term hoof problems lead to decreased milk production, decreased weight gain, reduced fertility, increase in premature culling and treatment costs.

# 2. Literature Review

Irish dairy farms use a grass based milking system which involves housing during the winter months to enable feeding when grass supply is limited on the ground. These housing facilities lead to prolonged contact or standing on concrete flooring which has been seen as an important factor influencing lameness in Irish herds (Boyle et al., 2006). A study carried out in the United Kingdom revealed the 4 most common causes of lameness as sole ulcers, while line disease, digital dermatitis (Mortellaro disease) and interdigital necrobacillosis. Research on the lameness in Dairy cattle carried out in Ireland occurs at the Moorepark Dairy Production Research Centre in Fermoy Co. Cork and the school of Agriculture, Food Science and Veterinary Medicine University College Dublin. At these institutes, Olmos et al., (2009) compared hoof disorders of cubicle based cows to pasture based cows and this demonstrated that cows at pasture had a quicker healing time if the lesion was present from housing period and those at pasture had an overall lower level of hoof lesions compared to those housed. This study also showed that White line disease can be attributed to the design and maintenance of walkways. Pasture cows are exposed to these walkways twice daily so mechanical insult from this can account for the occurrence of white line disease. On the contrary house animal are exposed to abrasive concrete surfaces in addition to walkways to and from the parlour which accounts for the higher incidence of sole hemorrhage/ulcer seen at this time. O'Driscoll et al., (2009) also reported that mechanical damage to the hoof horn tissue is a factor in the development of lesion. Abrasive concrete surfaces can increase the wear on the horn leaving them more susceptible to damage. Olmos et al., (2009) was also in agreement of this, in that sole lesions and white line disease are associated with the hoof undergoing exposure to harsh surfaces so the time spent on these types of surfaces will impact the occurrence of these diseases. As a large number of lameness issues in Ireland are caused by mechanical stress there is an on going need to reduce the external stressors on the feet (especially around the time of parturition). Blowey (2005) showed that cows preferred to walk along a softer more yielding surface. It is believed that the use of mats in Irish systems will decrease hoof lesions. Although this is the general belief, Boyle et al. (2006) conducted a study on this topic and found that there was no significant reduction in lesions when the mats were introduced. There is conflicting evidence with regard this, Vanegas et al. (2006) reported beneficial results, O'Driscoll et al. (2009) showed inconclusive results and Kremer et al. (2007) showed adverse effects. As lameness is a multifactorial disease all risk factors

must be evaluated pertaining to each individual farm before a definitive conclusion on the issue.

## 2.1 Causes of lameness

Lameness is a debilitating and painful condition and cannot be attributed to a single causing factor. This condition is a result of interactions between the animal and its surrounding environment, farm system and management in place and the breeding characteristics of the animal. All of these areas pose as potential risk factors contributing to the cause of lameness (Olmos et al, 2008). These factors alone may not result in significant lameness however a combination of these will have adverse effects on the hoof an animal.

Welfare and comfort of the cow has long been discussed and maintaining optimal hoof health is a problem encountered by all dairy farmers. The hoof is the weight bearing structure of the cow and its structure reflects its ability to fulfil its purpose. The main components of the hoof are the periople, the wall, the sole, the white line and the heel. Embedded within these structures are the pedal bone and the suspensory apparatus which allow for function of the appendage. As the hoof is a relatively small, confined structure and comes under huge pressures, its normal functioning requires sufficient blood supply to remain healthy. Even minute changes, from an internal aspect of the metabolic status of the cow or from external challenges from the environment can impact hoof health.

An internal factor affecting the hoof is that of parturition. The periparturient hormone relaxin is said to cause alterations in the pedal bone and suspensory apparatus system to allow for excess movement around this time. This process is under the influence of matrix metalloproteinase enzymes (MMP), these MMP's degrade collagen, weakening the suspensory apparatus. Tissue inhibitors of MMP's regulate this process to prevent excessive loss of collagen (Greenough, 2007, Tarlton et al., 2002). The weakening of the suspensory apparatus at this time along with the change in dietary composition correlates with the increase in solar haemorrhage and the white line disruption observed.

The external factors affecting the hoof are those involved in the intensive farming systems in place today. These systems provide an environment in which the cow has to endure longer standing times and more contact with harsh abrasive surfaces and have resulted in an increase in lameness in dairy herds as the claw is more susceptible to lesions from its surroundings (Greenough and Vermunt, 1991). Studies have shown that cows kept on concrete have excessive wear on the claws as this surface cannot provide enough friction to maintain a good support holding for the cow. When covered in manure slurry the natural locomotion behaviour of the cow is hindered (Cook et al., 2009). These will be discussed further in the following points.

## 2.2. Environmental Factors

The ideal environment should be provided for dairy cattle, if this is not fulfilled, it may induce stress, which will in turn predispose the animal to disease, including those causing hoof disease. (Greenough, 2007)

### – 2.2.1. Housing and Walkways

The type of housing is an integral part of maintaining a good health status of the dairy cow. Cow comfort has long been investigated; as the intensity of farming has increased, the natural environment has decreased. Nigel B Cook (2009) suggests that the physical comfort of the animal, including the standing surfaces and the lying areas in which it is housed is an important factor influencing the lameness incidence in the herd. Farming systems in place in Ireland involve a period of housing, therefore the cows are subjected to contact with hard abrasive surfaces like concrete, slatted floors, cubicle housing with alleys with scrapers etc. These loose housing systems ultimately affect the hoof health of the cow as she is exposed to a harsh surface and if there is inadequate drainage, more time will be spent standing in slurry and moist surfaces (Hultgren et al., 2001). Slatted floor provides a dryer surface for the hoof of the animal, thus leading to less softening resulting in a lower incidence of horn heel erosion compared to concrete floors

(Somers et al., 2005). Slatted floors have the advantage of better drainage thus promoting a dryer surface, however it still has an abrasive none yielding surface that the cows is forced to adapt to. Rubber matting has been integrated into some farms to try and improve this. Studies have shown that cows prefer to walk or stand on these more yielding surfaces if given the option (Boyle et al., 2006). Housing can also affect the lying times of the cow which also has an effect on the occurrence of lameness and hoof problems of the cow. In an ideal situation the dairy cattle should spend about 14 hours lying in an average of 8 lying bouts in the day (Grisel Navarro et al., 2013). This study showed a difference in lying time between lame and non-lame cows of almost 2 hours. Misshapen feet, sole and wall damage and infectious diseases were the ultimate causes of this difference. Gomez et al. (2010) shows that lame cows have less lying bouts possibly due to the pain associated with rising and they may stand for longer because the process of lying poses more of a challenge when lame. Chapinal et al., (2010) also discussed the type of bedding, if there is a threat of slipping the lame cow will be even less inclined to rise even if hunger or thirst is the reason for the need to rise. Hierarchy can also impact lying time, heifers that have not been integrated properly into a herd have been seen to have a lying time of as low as 6 hours, there was also a correlation between this and these animals showing the most severe lameness.

As the farming system in Ireland involves grazing for many months, walkways and pasture are also factors involved in maintaining hoof health. Pastures located at distances away from the milking parlour forces the herd to increase its walking time, hence increasing the risk of mechanical damage to the hoof (Cook et al., 2004). O' Driscoll et al. (2009) shows that sole lesions in particular are associated with the hoof being exposed to harsh surfaces. Walkways on most Irish farms consist of gravel based substances and with constant wear from the walking of herds two times daily it can lead to stones being uncovered, exposing the hooves to very undesirable surfaces ultimately leading to sole lesions.

- **2.2.2. Feeding and Nutrition**

While over exposure to hard abrasive surfaces, damp housing conditions, exercise and the gestational status of the dairy cow may predispose her to claw lesions, nutrition is also a factor that should be considered. A study (Leach et al., 2005) shows that the type fodder fed to animals can have an impact on the production of a lesion. It shows that those fed on a grass silage based diet showed a higher incidence that those fed on an unfermented straw based diet. This study also provided information regarding the housing environment as those cattle fed the wet form of the diet produced less viscous dung than those on the dryer diet, ultimately providing a wetter environment in which the cows had to live. This subjected the hooves to wetter surroundings and proposed that this allowed for better softening of the hoof, rendering it more susceptible to damage as the soft horn is less able to produce a strong protective capsule. As good hoof quality is the main barrier in the prevention of lameness and hoof lesion adequate nutrition is required for its production (Greenough and Vermunt, 1991). Horn is produced by epidermal living cells. These are very active cells that move slowly towards the outside of the foot and accumulation of these are responsible for producing keratins and provide mechanical stability of the horn, for the survival of these cells adequate oxygenation and nutrient supply is constantly required (Muelling et al., 2009).

Laminitis, or inflammation of the corium, can occur sub clinically and cause minor changes to the corium, but these changes can affect horn production for the rest of the cow's life. (Speed J. 2006) A significant number of lameness cases can be seen post calving (approx. 8 weeks). This time frame suggests that feeding pre and post calving nutrition has an influential factor on hoof production (Westwood et al., 2003, Cook et al., 2004). Abrupt changes in the type of diet provided to the animal (dry cow ration to lactation ratio) as well as diets that are low in fibre are known as risk factors in the initiation of hoof disorders like laminitis, sole ulcers and heel erosion (Cook et al., 2004)."Puffy feet" is a term used to refer to the swelling and pinking up of the skin around the bulb of the heels at the time of calving (Greenough, 2007). At this time the hoof is soft and renders it more susceptible to external damage, however the change in nutrition at this time may be overlooked as an additional factor in the cause of lameness. A

lactation ration high in concentrates can change the pH in the rumen and require a gradual introduction to allow the rumen to acclimatise to this in order to prevent acidosis (Kaufmann, 1976).

Acidosis is a lowering of rumen pH, and results in the production of excess lactic acid and also supresses the production on biotin synthesis, both of these hinder the normal horn production. Blowey (2008) shows that amino acids especially those containing sulphur, minerals and vitamins especially zinc, calcium and biotin are essential for normal hoof development. All of these are supplied though the blood vessels that supply the hoof so monitoring the nutritional intake of the cow particularly pre and post parturition is advantageous in preventing acidosis or other metabolic disorders that negatively affect horn production (Muelling, et al., 2009)

- **2.2.3. Stockmanship**

The way in which a herd are managed contributes to the incidence of hoof disorders and diseases within the herd. Knowledge of the changes in environment and how these impact the hoof health is of utmost importance in keeping lameness incidences as low as possible (Greenough, 2007). Walkways and collecting areas pose threats to the hoof of the cow as these areas are more often than not unfavourable and uneven surfaces for hoof placement. Poor herding skills along with poor roadway quality can lead to an increase in lameness in dairy herds kept on pasture (Olmos et al. 2009). Impatient handling of cows had been demonstrated to have an influence on the incidence of lameness. Research shows that cows that were forcibly herded along a track or passageway by an inexperienced/impatient stockman had higher incidences of lameness than those that were allowed to walk at their own pace (Clarkson and Ward 1991). This lameness is associated with the placement of the feet during walking, those that are hurried along show a different stance than those allowed to move freely. In rushed movement the cows carry their heads high and this doesn't allow for careful foot placement, resulting in the higher incidence of trauma to the hoof (Blowey, 2005).

### – 2.2.4. Breeding

Many studies show that there is significant genetic variation for traits associated with hoof health implementing that selection for good hoof health may have an improved outcome on dairy herd's welfare and productivity (Emanuelson et al., 1998, Van Der Waaij et al., 2005). Emanuelson et al. (1998) also suggests that selection solely on the milk production trait will increase the genetic predisposition to poorer hoof health and ultimately lead to an increase in lameness. Other studies also agree with this and state that using this trait for selection within the Holstein Friesian breed is associated with an increase in premature culling in dairy herds (Rauw, et al., 1998). Politiek et al. (1986) reported that there is a genetic variation within breeds for hoof lesions and hoof conformation, this study also highlighted that claw morphology was a genetic trait that is hereditary. So these traits should be taken into account when sire selection is decided. Olmos et al. (2008) proposed that when selecting for breeding, the genetic merit for survival, fertility and health as well as milk production should all be included and may result in a favourable outcome in reducing the incidence of lameness in the herd. Economic Breeding Index (E.B.I.) is the Irish selection index used to select and identify animals that will potentially have profitable progeny. This index place emphasis on the fertility, health and milk production and was used when selecting animals in this study. Oberbauer et al. (2012) reported that some hoof lesions had a higher association with farm management and that this contributed to the expression of a particular disease. It is found that foot rot and claw horn lesions were heritable but had a higher incidence when associated with poor hygiene conditions. Koenig et. al. (2005) found that sole ulcers and foot warts had the highest estimated heritability and these particular lesions increase with the increasing parity of the cow. This study also showed that there is a correlation between genetic selection and management so improving in one of these aspects may lead to an improvement in the other.

## 2.3 Common Hoof Disorders and Diseases

At present there are a variety of hoof diseases and disorders commonly seen on dairy farms. These range from infectious to non-infectious disorders. The non-infectious types can be summarized under a general heading of Laminitis.

Laminitis is an aseptic inflammation of the dermal layers inside the hoof. As discussed earlier metabolic or digestive disorders in the cow can lead to this inflammation. The disruption to the vasculature in the corium affects the function of the tissues with which it supplies, particularly the epidermal living cells responsible for the keratin production.

Laminitis can be seen in varying degrees, from subclinical, acute or chronic depending on the severity of the factors initiating the insult to the hoof (Greenough, 2007). As previously noted, laminitis is not caused by a single factor, so environmental stresses have to be considered at all times as they can be the cause or can exasperate the symptoms of laminitis. This is especially seen around the time of parturition when the hoof is rendered more susceptible to external damage due to the hormonal changes leading to softening of the hoof (Tarlton et al., 2002). The introduction of a lactation diet can also be the causative agent of laminitis usually of a sub clinical nature. This occurs when there is insufficient time allowed for acclimatising of the rumen papillae to the new diet. A sudden change in the feed causes a release in vasoactive substances dilating the digital blood vessels causing a rise in pressure within the hoof. When this increase in pressure is combined with environmental factors like the change in housing or movement to pastures, there is a decrease in the structural stability of the hoof, as there is softer than normal horn being produced so will indefinitely lead to lesions being seen in the following weeks.

Acute laminitis is usually seen in animal(s) that have accidently gained access to large quantities of grain and sub acute laminitis is a common condition seen in feed lot bulls that are fed a high carbohydrate ration (Thoefner et al., 2004)

## Sole Ulcers

Sole ulcers usually appear on the lateral claw of the hindlimb. Raber et al., (2004) proposed that lesions from disruption of the claw are a direct result of contusions from the mechanical impact suffered by the hoof. As the lateral claws of the hindlimb receive higher vertical pressure than those of the medial claws, it is accepted that the majority of sole ulcers are seen on this limb (Phillips, et al., 2000). These lesions are typically seen at the central solar area towards the heel. The ulcer can be covered by a layer of horn which may sometimes show discolouration (Figure 1 and 2).

More often than not these lesions are not identified until routine trimming as the hoof can look normal and on inspection of a clean hoof a slight discoloured area may be seen or may be exposed during trimming. A pressure test allows for the distinction between an open and a closed ulcer. If there is no reaction to pressure the ulcer is closed so preventative treatment is still possible whereas if there is a reaction to pressure the ulcer is opened and the loose horn will have to be removed. As the rate of hoof growth is approximately 6mm of hoof wall per month (Drivers and Peek, 2007), the position of the sole ulcer can be tracked back to the time of the initial insult to the hoof.

Sole ulcers are usually slow to heal as there has been damage to the horn producing tissue, therefore new horn is much slower to form, indeed some ulcers never fully heal and result in chronic lameness and corrective trimming up to four times a year.

Figure 1

Figure 2

Treatment of sole ulcers must be aimed at trimming the sole as much as possible so that the weight and subsequent pressure is removed from the affected area. The sound claw should be left large enough to bear the weight or alternatively apply a lift block/shoe to the ipsilateral claw. Bandaging is not advised as it can increase the pressure of the affected area. If there is granulation tissue protruding it should be removed to the level of the surrounding epidermal tissue to encourage the living cells to invade the granulated area.

## Toe Ulcers

Toe ulcers affect mature cows. This lesion starts as a small haemorrhage in the while line area of the toe (figure 3). The cause of this is not well understood and may stem from many factors. Rotation of the pedal bone within the capsule, the release of MMP's (similar to what occurs at parturition) causing the breakdown of the suspensory apparatus therefore weakening the suspension of the pedal bone is deemed to be a major cause. Disruption to the flow of the circumferential artery in this area after the sudden intake of high energy ration may also yield the same lesion. This is a relatively new lesion and only became apparent when regular trimming and lameness observation became more important in the health status of a herd (Greenough, 2007)

Figure 3

Treatment is dependent on the severity of the lesion. The affected area should be trimmed so healthy dermis and granulation tissue are present and if necessary a protective covering containing an antibiotic impregnated gauze can be applied.

## White Line Disease

The white line is the junction between the wall and the sole of the hoof. It is composed of cells cemented together and because of this it serves as a point of weakness as it may be penetrated or impacted easily. In white line disease the fibrous junction disintegrates and is penetrated by debris (dairyinfo.biz) this lesion is seen predominantly on the lateral claw of the hindlimb as this area it the most weight bearing point and makes contact with the ground. Both hind limbs may be affected at once masking the lameness in the locomotion of the cow, however as the animal walks the affected limb may be swung out and away from the body during each step taken or she may stand with the medial claw bearing the majority of the weight (Greenough, 2007).

White line disease is commonly seen at regular hoof trimming and may present as a stone penetrating this area, which may act as a wedge between the wall and the sole. Once debris impacts this area the hoof closes quickly around it and there is no longer a point of escape for the developing pus from the point of entry. The infection may localise here or penetrate further forming a retroarticular abscess (figure 4). Once the development of pus commences, it causes an increase in pressure in the hoof and it is this rise in pressure that results in the pain causing the lameness. The degree of lameness is dependent on the rate of the pus production within the hoof. It is this reason that some white line diseases that are seen at trimming are not represented with the associated lameness as it may not have had time to develop into a pus producing lesion. Because of this, regular hoof trimming is essential in preventing the development of the more severe cases of those debilitating disease. During trimming all of the while line must be cleaned and inspected thoroughly. Any dark marks must be investigated and trimmed away in order to expose any pus forming lesions.

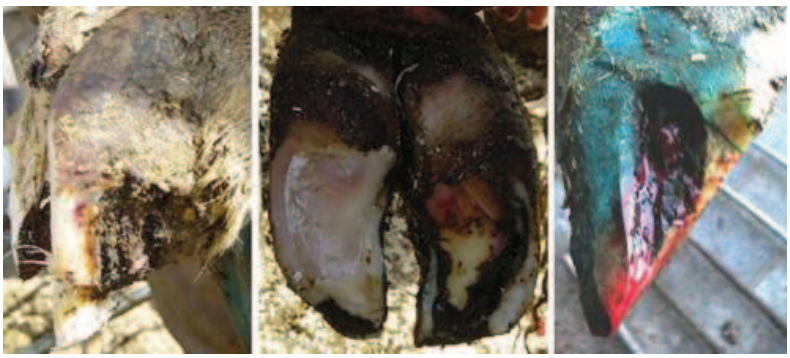

Figure 4

Overall treatment of white line disease, irrelevant of its severity involves draining of the abscess to relieve the pressure in the hoof. Blowey (2008) states that it is important to remove a part of the wall beside the infected area to serve as a drainage track for the lesion. The application of a shoe/lifting block to the sound claw has its advantages also as pressure is removed from the affected claw. Drainage of more severe lesions may be required for some days preceding the diagnosis.

## Horizontal Fissures/ Hardship Groves

This is one of the most prevalent changes seen in Irish dairy herds. This is a depression/groove/fissure running around the entire wall of the claw (Figure 5). The groove usually runs parallel with the hair line (Figure 6). These lines usually go unnoticed until they have grown down towards the toe. A bout of severe illness like e-coli mastitis, toxaemia or a metabolic disorder like photosensitisation or the stress of a severe calving can lead to a total but temporary cessation of the production of horn. These lines are an indication that the animal was subjected to a short term stress like those stated above. As the fissure grows down towards the toe it is referred a thimble, as it passes down it loses attachment at the heel and movement can occur between old and new horn (Blowey, 2008). This can cause discomfort and pain to the cow as the fissure is still attached to sensitive tissue. The disturbance between the old and new horn is also a weak point for the entry of debris and small foreign bodies which can lead to infection (Greenough, 2007) However this is not always the case, generally less severe fissures do not cause obvious discomfort to the cow and break off at the toe without the incidence of infection. More severe thimbles should be trimmed away if possible and a shoe/lifting block applied to the sound claw of necessary

Figure 5

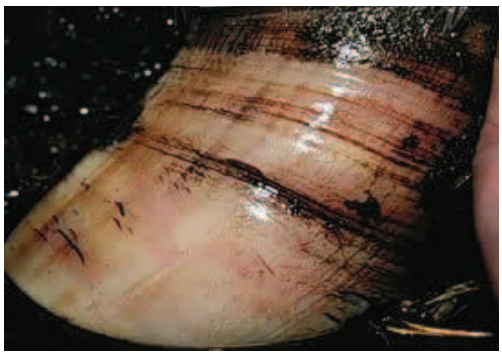

Figure 6

## Infectious Hoof Diseases

### Digital dermatitis/Mortellaro's Disease

Digital dermatitis is an acute inflammation of the hairy skin surrounding the hoof. It is a very painful disease with erosive ulcerations (Refaai, et al. 2013) Cleaning off the affected area exposes a reddened area containing granulation tissue. Murray et al. (1996) describes this as one of the most contagious and hygiene dependant diseases.

Typical appearance of the lesion is that of an oval structure, outlined by demarcating borders and with hair growing around it. It has a distinctive odour (El-Ghoul and Shaheed, 2001).

Lesions are usually found on the plantar aspects of the hindlimbs, affecting the skin of the interdigital cleft or the skin surrounding the bulbs of the heels (Figure 7). A severely affected animal will show lameness, may hold its foot from the ground or may be forced to walk on its toes (Read and Walker, 1998)

Digital dermatitis is a bacterial infection of the skin. The causative agent of this disease is controversial. However spirochetes have been isolated from lesions of digital dermatitis. Two specific genera have been isolated that of the Borreli spp. and the Treponema spp. these spirochetes proliferate around the basal layer of the epidermis and cause erosion of this tissue or result in the proliferation of this, so these either kill the living epidermis or cause it to from new epidermal tissue at a higher rate than normal (Greenough, 2007).

Figure 7

Treatment of the disease is important. Once this had been identified all hooves of all animal must be inspected as it is highly contagious. The lesions must be thoroughly cleaned to allow for the topical administration of antibiotics. A bandage must be placed over the treated area for several days in order for the treatment to work (Blowey, 2008)

**Bovine Interdigital Necrobacilosis (Foul in the foot)**

This disease is also commonly known as interdigital phlegmone or footrot. This disease is caused by a bacteria known as Fusobacterium Necrophorum and Bacteroides Melaninogenicus is thought to be associated with it. Both of these bacteria are commonly found in the faeces of the cow and it is believed that injury to the skin by penetrating stones etc. provides an entry point for invasion (Blowey, 2008). The overall incidence of this disease is low however it is an extremely painful condition resulting in a negative economic impact on a dairy herd.

The appearance of footrot usually presents a typical picture. It begins as a swelling between the claws and usually occurs with a sudden onset (within 24hrs of infection). This swelling leads to separation of the toes yielding a very painful foot and the animal will show considerable lameness at this point (Figure 8 and 9). The swelling of the skin will yield a crack in its surface a yellowish tissue exudate emerges from it and has a characteristic odour. This discharge also serves as a source of infection for other animals. There will be a higher incidence of this disease in wet, abrasive and unhygienic environments. All animals are susceptible to the disease if correct conditions are present but those that are particularly sensitive to infection are recently calved cows (due to the softening of the hoof at this time)

Maas J., 2009).The animals also show a rise in temperature, a very rapid drop in milk yield, and a decreased feed intake. This will continue as long as the animal is in pain.

Figure 8

Figure 9

Prevention is easier than treatment in the incidence of this disease. Regular foot bath with chlorotetracycline or copper sulphate are an effective way to control the disease. If an outbreak occurs the environment in which the animals are living should be investigated for any sharp penetrating objects that may be serving as a point on entry for the infection. In the event of an outbreak rapid treatment with antibiotics is necessary to prevent the infection spreading to the joint itself.

## Horn Heel Erosion

This is a very prevalent lesion of dairy cattle during the housing period. It affects both the skin and hoof tissue. Mild cases don't usually render the animal lame and only inflict mild discomfort. As the name suggests it is caused by contact with slurry and abrasive surfaces encountered during housing. Older multiparous cows show a higher incidence of this disease (Chapinal et al., 2010), as their hooves and underlying structures have undergone much more stressors than those younger animals. If the erosion continues to worsen, the horn heel is gradually destroyed and balance of the claw is upset (Figure 9). This is when we see prominent lameness in the animal. The cow tries to compensate for the loss of heel by moving her weight forward, which can lead to higher incidence of sole haemorrhages and ulcers. However with good surveillance of herd today this disease doesn't usually persist until such conditions are reached.

Figure 10

Treatment

If lesions are persistent a regular footbath containing formalin is sufficient to inhibit heel erosion. Usually preventative measures like maintaining the environment and removal of slurry are enough to minimise the disease.

## 2. Materials and methods

This study was carried out on 5 dairy farms in the East Galway region of Ireland. All of these herds are spring calvers with an estimated calving date from the 15th of February to the 30th of April depending on the farm. Data was collected from November 2012 until July 2013. Majority of dairy herds in Ireland use a grazing pasture system from spring until October and then house the animals and feed fermented grass silage during the winter months.

Hoof disorders were recorded on each affected limb. The locomotion of all animals was observed during walking times to the milking parlour. If there was a deviation from normal speed, posture or the cow showed signs of head bobbing, the hooves were initially investigated in the milking parlour and further assistance was sought if it was deemed necessary.

The severity of lameness observed by the farmers ranged from:

- Sound, those showing no signs of lameness
- Mildly lame, those exhibiting slower pace than normal but no real deviation from normal locomotion
- Lame, those favouring the affected limb, proceeding at a slower pace and some head bobbing to counteract the different weight distribution
- Severely lame, those animals showing all signs listed above but at a higher level

Animals that were characterised as mildly lame were assessed by the farmer and if the cause of the lameness was not uncovered the hoof trimmer was requested. Those that were lame or severely lame were assessed and treated by the hoof trimmer initially and if needed by the veterinary surgeon.

The total number of animals observed on the 5 farms was 409 and of these, lameness was observed and treated in 62 animals. The types of diseases that occurred were sole hemorrhage/sole ulcer in 35 cows, white line disease in 11 cows, slurry heel in 2 cows, digital dermatitis/mortellaro in 13 cows and foul in the foot in 1 cow. Sole hemorrhage on these farms is regarded as a predisposing condition to sole ulcer if left untreated

As the housing facilities, walkways to and from the parlour, and general assembly and standing areas pose the most threat to the condition of the hooves, particular attention was focused on these areas with regard to the following:

Housing;

- Type of flooring in place
- Condition of the flooring
- Use of rubber mats
- Use of automated scrapers
- Cleanliness of lying areas

Walkways and assembly areas;

- Type and condition of surface
- Wet or dry surfaces
- Maintenance/loose stone removal

Information of the feeding regime was based on information received by each farmer.

As the study began in November the in calf cows and heifers were already segregated according to the stage in gestation so recording and observing their incidence of lameness was straight forward.

## 3. Results

Within the farms there was 409 animals observed for lameness. Theses farms were chosen as they had similar calving periods, feeding regimes, housing facilities and hoof trimmings when required. The following results are those which were found pertaining to each farm.

### FARM 1

This farm has a total of 85 milking cows. The standard of hygiene and lameness control is excellent on this farm. The layout of the farm is structured around the milking parlour.

The housing facilities are maintained to a very high standard. The design of these include 3 sheds containing cubicles. The cubicles back onto a dunging and are serviced by automated scrapers every 4 hours. The cubicles themselves are all fitted with rubber mats and lime is spread on the surface of these as needed. The lime serves as a neutraliser of bacteria and also prevents excess precipitation and dampness in the housing.

The pastures for grazing are all located within a 1km radius connected by self-maintained walkways. The walkways are inspected daily during grazing season and the concrete in the holding yard is washed after every milking and swept each evening to remove any loose debris.

The cows are also segregated according to their age, the replacement heifers are housed in an adjoining barn that is separated from the mature cattle by a low wall so still allows for socialising without there being a threat of aggression from hierarchy.

The adjoining shed to the replacement heifers is the close up area where the dry cows are housed, so the transition to the close up area is not a hugely stressful event for the replacements as they are already familiar with the surroundings.

From 3 weeks prior to expected calving date, rolled oats are introduced slowly in to the grass silage based diet. The rolled oats allows for slower energy release so the rumen can acclimatise to the change to decrease to incidence of SARA and sub-clinical laminitis. 1 week before expected calving date the cows are moved to the calving pens and fed ad libitum hay and some concentrate (Figure 14). In this area each cow is housed separately on straw bedding with saw dust and remains there for at least 2 days or longer post partum if the pastures are not suitable for grazing in early February. This bedding is changed and the pen cleaned out after every cow to minimise the dampness and spread of bacteria.

This farm takes all precaution possible to minimise the occurrence of lameness. It is a closed herd and has no incidence of digital dermatitis for 5 years now.

**Table 1: FARM 1**

| Group | No. of lame animals | Lameness | | |
|---|---|---|---|---|
| | | Slightly Lame | Lame | Very Lame |
| Dry Cows | 1 | | 1 | |
| Freshly Calved | 0 | | | |
| Post Calving 4 weeks | 1 | 1 | | |
| Post Calving 8 weeks | 1 | 1 | | |
| Housed | 2 | | 1 | 1 |
| Total | 5 | 2 | 2 | 1 |

The total percentage of animals lame in this farm is approximately 6% and 80 animals showed no sign of lameness.

Figure 11: walkway

Figure 12: cow resting in rubber mat lines cubicle with lime on surface

Figure 13: feeding and resting area

Figure 14: calving pens

**FARM 2 & 3**

Farm 2 and 3 have been grouped together as the differences in their housing systems and walking times from grazing were minimal.

Farm 2 has a total of 75 milking cows and farm 3 has 82 milking cows. These farms were originally established many years ago with smaller herds. As a result of this the milking parlours are not situated at the centre of the farm. As a result the walking distance from the housing is approximately 0.5 km and during grazing the furthest paddock is between 1.5 and 2km, resulting from this more time is spent walking to and from the parlour. The walkways to the paddocks are inspected regularly and maintenance done as soon as possible. The main walkway to the parlour is cleaned daily however the rest of the yard is only done twice weekly so there may be a slight build up of dung which coupled with the climate of rain leaves areas of pooled, dirty water infiltrated with faeces, resulting in unhygienic conditions (Figure 15 and 16). The increase walking time affects the lying time of the animals as they subject to more exercise and harsh walking condition for longer periods than desired. Both of these farms have slatted shed housing facilities with cubicles situated in each shed, rubber mats are not used by these farms. The quality of the slatted flooring was good and no evident damage was seen. These facilities allowed for a small but constant amount of wet dung on the surface of the slats at all times as there is no scraper to remove it. All sheds were well ventilated with openings at bit ends to prevent build up of ammonia.

All cows are housed together in the dry period and are separated approximately 1 month before their due date. A lactation concentrate (dairy nuts) are introduced to these from this time up to calving. Replacement heifers are housed separately and are not mixed with mature cows until they are put out to pasture.

Both of these herds also reported incidences of digital dermatitis (Mortellaro) in some animals. These animals were placed in a separate holding after receiving treatment from the hoof trimmer and foot baths were put in place for 1 week after the diagnosis. Farm 2 had one other incidence of it and farm3 had four.

**Table 2: FARM 2**

| Group | No. of lame animals | Lameness | | |
|---|---|---|---|---|
| | | Slightly Lame | Lame | Very Lame |
| Dry Cows | 3 | 1 | 2 | |
| Freshly Calved | 3 | 2 | 1 | |
| Post Calving 4 weeks | 1 | 1 | | |
| Post Calving 8 weeks | 0 | | | |
| Housed | 4 | | 2 | 2 |
| Total | 11 | 4 | 5 | 2 |

The total percentage of animals lame in this farm is approximately 14% and 64 animals showed no signs.

Figure 15: dung in standing area, example of dirty environment

Figure 16: wet, unhygienic, dirty condition

**Table 3: FARM 3**

| Group | No. of lame animals | Lameness | | |
|---|---|---|---|---|
| | | Slightly Lame | Lame | Very Lame |
| Dry Cows | 1 | 1 | | |
| Freshly Calved | 3 | 2 | 1 | |
| Post Calving 4 weeks | 2 | 2 | | |
| Post Calving 8 weeks | 1 | 1 | | |
| Housed | 5 | 1 | 2 | 2 |
| Total | 12 | 7 | 3 | 2 |

The total percentage of animals lame in this farm is approximately 15% and 70 animals showed no signs.

Figure 17: walkway showing poor maintenance

Figure 18: cubicles in slatted shed

**FARM 4**

This farm has a total of 76 milking cows. The facilities include slatted sheds with cubicles but also non slatted resting areas with cubicles services by an automated dung scraper (Figure 19 and 20). The usage of lime in the cubicles was introduced in December in a bid to reduce bacteria numbers in the sheds. No rubber matting is used. The areas with the scraper were well maintained and no surface was seriously over run with dung, however some of the slatted areas were heavily covered in dung and combined with urine served as a chemical stress on the hooves reducing the mechanic strength of them Figure 19). The dry cows are separated out from the herd 2 weeks before the expected due date and are placed in a small paddock with access to shelter at all times. Replacement heifers are integrated into the herd once their pregnancy status is verified. There is no introduction of a lactation ration prior to calving. This ration is just given at milking times only. The milking parlour is also at the border of this farm. The walkways from the housing is poorly designed in that the concrete is set at different levels in certain areas and there are also some sharp narrow turns to be negotiated putting extra pressure on the hooves (Figure 22). The paddock are within 1km of the parlour however some of the walkways to these have access to the public so are very hard to maintain leading to very poor surfaces on which the cattle are forced to work on. Very impatient stockmanship of an employee

was also reported which coupled with the conditions of the surface leads to increased hoof problems.

**Table 4: FARM 4**

| Group | No. of lame animals | Lameness | | |
|---|---|---|---|---|
| | | Slightly Lame | Lame | Very Lame |
| Dry Cows | 5 | 2 | 2 | 1 |
| Freshly Calved | 3 | 2 | 1 | |
| Post Calving 4 weeks | 3 | 3 | | |
| Post Calving 8 weeks | 1 | 1 | | |
| Housed | 6 | 1 | 3 | 2 |
| Total | 18 | 9 | 6 | 3 |

The total percentage of animals lame in this farm is approximately 24% and 58 animals showed no signs.

Figure 19: cubicles in slatted shed

Figure 20: cubicles with scraper

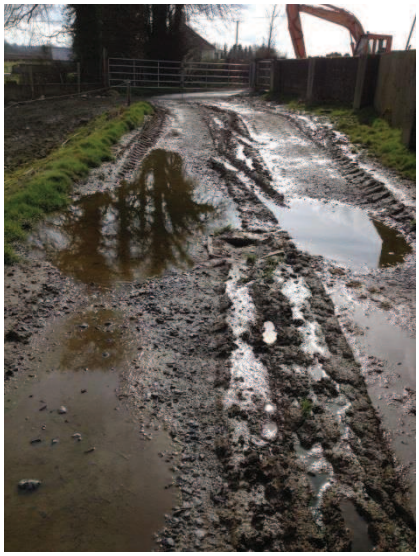

Figure 21: poorly surfaced walkway

Figure 22: uneven, broken surface of yard

Figure 23: acute angle into milking parlour

**FARM 5**

This farm has a total of 91 milking cows. This farm is currently in the process of updating all the roadways leading to and from the parlour (Figure 26). The housing facilities are that of slatted flooring only (Figure 25), in one shed and slatted flooring with cubicles in the others. During the housing period the cattle are rotated between the cubicle and non-cubicle shed. A build-up of dung was observed at the end of the slatted shed as the slatted flooring did not run the full length of the shed. Due to the use of the non cubicle housing the cow are subject to an area of less comfort, which reduced the amount of time spent lying in this area. The replacement heifers are placed in a pen adjacent to that of the mature cows. The cows are monitored daily and moved to a resting area 2 weeks from expected date of calving. A lactation ration is introduced at this time. The walkways from the housing to the parlour are concrete and in very poor condition with very many cracks present, (Hence the improvements) the walkways from the pastures span approximately 0.75km and have been resurfaced with gravel before the grazing season begins in a bid to reduce that lameness in the herd. The yard and facilities are kept at a good standard of hygiene and build-up of dung doesn't occur as it is cleaned on a daily basis.

**Table 5: FARM 5**

| Group | No. of lame animals | Lameness | | |
|---|---|---|---|---|
| | | Slightly Lame | Lame | Very Lame |
| Dry Cows | 4 | 2 | 1 | 1 |
| Freshly Calved | 2 | 1 | 1 | |
| Post Calving 4 weeks | 2 | 2 | | |
| Post Calving 8 weeks | 1 | 1 | | |
| Housed | 7 | 2 | 3 | 2 |
| Total | 16 | 8 | 5 | 3 |

The total percentage of animals lame in this farm is approximately 18% and 75 animals showed no signs.7

Figure 24: slatted flooring

Figure 25: slatted house w/o cubicles

Figure 26: gravel roadway

Figure 27: cubicles with scraper

The types of lameness recorded on all farms were recorded in table 6:

**Table 6**

| FARM | TYPE | AFFECTED LIMB |
|---|---|---|
| **FARM 1** | 2 sole hemorrhage | 2 right hind limb |
| | 3 sole ulcer | 1 left hind limb |
| | | 2 left hind limb |
| **FARM 2** | 2 mortellaro | 2 left hind limb |
| | 2 white line disease | 1 left/ 1 right hind limb |
| | 4 sole hemorrhage | 3 left/ 1 right hind limb |
| | 3 sole ulcer | 2 right left hind limb 1 left fore limb |
| **FARM 3** | 5 mortellaro | 5 left hind limb |
| | 1 white line disease | 1 left hind limb |
| | 6 sole ulcer | 4 right hind limb/ 2 right fore limb |
| **FARM 4** | 6 sole ulcer | 5 left hind limb/1 right fore limb |
| | 4 white line disease | left hind limb |
| | 2 slurry heel | left hind limb |
| | 6 mortellaro | 1 left for limb/5 left hind limb |
| **FARM 5** | 11 sole ulcer | 5 left/4 right hind limb/2 right fore limb |
| | 4 while line disease | 3 right hind limb/1left hind limb |
| | 1 foul in the foot | right hind limb |

## 4. Prevention and control

The prevention and control of lameness is an on-going issue in the everyday life of Irish farmers. As it has been pointed out the environmental factors can influence the incidence of lameness so every aspect of this should be investigated to improve the issue. Other tasks that can aid in both the prevention and control are hoof trimming and foot baths. Both of these methods are carried out on the farms on a "Needs Be" basis, it was recommended that hoof trimming be introduced on a bi annual basis, so that some of the severe lesion may be avoided through early detection. Foot baths are a more costly labour intensive job so this will remain in place only when required on the farms.

Methods of prevention and control according to Bell, (2009)

- **Regular hoof trimming**

  *Dutch 5 Step Method*

  Routine Foot Trimming

  1) Trim toe length to 7.5cm from the coronet, where the horn starts. The cut must be perpendicular to the sole. Trim back the sole to a thickness of 0.5 - 0.8cm at the tip of the toe and leave the thickness of the bulb or heel as it was. Save the height of the heel.

  2) Match untrimmed claw to this. Do this by cutting back the length of the outer claw to the same length as the inner claw and trim the sole to an equal height as the inner claw (if possible). In case of a claw with laminitis, it may not be a possibility to reach the same height in the toe. The heel or bulb is more important, because it bears most of the weight.

  3) Dish soles by modelling: Trim the claws into a slightly hollow shape, starting 2.5 to 3 cm from the toe towards the heel. This will keep the space between the claws clean and airy (preventing inter-digital dermatitis / slurry heel).

  Corrective Trimming

  4) Relieve weight off painful claw. : If there is a defects like sole ulcer and or wall ulcer this claw must be trimmed down further. This creates a height difference between the healthy and damaged claw and the weight bearing is partly transferred to the healthy claw. The damaged claw can heal more quickly. In case of too little height difference a block may be applied to the healthy claw to raise

its height. In case of bruising of the sole, a height difference can be made, but don't trim the sole too thin. In step two the excess weight is removed and this is normally enough relief for the claw. Step 4 is not needed during preventative trimming.

5) Remove loose/under-run horn and hard ridges at the heel area of the claws. Be careful in the inner claw: here only the fissures in the heel are removed, any further loose horn is not a problem. Removing it will affect the stability and the height of the claw. In the outer claw loose horn and ridges have to be removed in the last two-thirds of the sole surface. At last check the feet for digital dermatitis.

– **Foot baths**

Foot baths may be seen as an inconvenient due to the expense and extra work involved. Also the chemicals used have to be disposed of correctly. Nevertheless a study by Randhawa et al., (2008) showed an improvement in many lesions causing lameness. The foot baths treat infections like digital dermatitis and foul in the foot, clean excess slurry off and disinfect the hoof to prevent bacterial overgrowth and harden the claw and the skin around the claw. Foot baths in combination with antibiotic treatment has been seen to reduce in signs of lameness quicker that antibiotic treatment alone.

(http://www.nadis.org.uk/bulletins/lameness-control-in-dairy-herds/part-6-foot-bathing.aspx)

The following foot bath can be used as control of disease:

– 5-10% formalin (but cruel for cows with open sores so treat some or whole herd with formalin or copper sulphate first)

– 5-10% copper sulphate

– 5-10% zinc sulphate

To maintain goof hygiene and disinfection:

– organic acid foot baths

– 2% hypochlorite

– Pasture

– Straw yards

– 2-10% formalin, copper sulphate or zinc sulphate (2% is bottom of effective range – strength needed for last cow through)

Recommended rotation for these products is:

Week 1: 5% Copper sulphate

Week 2: 5% Formalin

Week 3: 5% Zinc sulphate

## 5. Discussion

As numerous studies have shown, lameness and hoof disease are a result of many contributing factors and have a huge impact on the welfare of the cow. From this study, 5 Irish Dairy farms showed varying incidence of lameness but this correlated with varying facilities and hygiene systems in place.

Farm 1 demonstrated excellent standards of hygiene and animal welfare. The farmer believed that these are a high priority in getting the best results from his herd. A combination of the rubber mats, lime, cleanliness (figure 12) and excellent roadway maintenance (figure 11) account for the low incidence of lameness in this herd. This correlated with the findings in Boyle et al, (2006) which shows that rubber mats will favour the comfort of the cow and reduce the standing times on concrete leading to less trauma on the hoof. Within this study Boyle also found that good concrete condition, short walking distances and removal of debris coincides with no severe sole hemorrhage or ulcer. This farm demonstrated this perfectly as only a total of 5 animals were reported lame within the observation time (table 1).

Farm 2 and Farm 3 have a higher percentage of lameness but also has longer walking time to the parlour. A study by O' Driscoll et al. (2009) showed that cows with less walking time had lower sole lesions as the hoof was not exposed to as much mechanical damage. Even though maintenance is high priority, the roadways have very poor drainage and after rainfall, water gets lodged along the sides of the tracks (Figure 17). This had an impact on the cows as they are subjected to more exercise on poor surfaces and therefore can affect the lying times of them so more time is spent standing  The housing facilities and lack of rubber mats may also impact this. Livesey et al. (1998) established a positive correlation between an increase in lesions of the horn and prolonged standing time on concrete. Vokey et Al. (2001) also stated that the abrasiveness of concrete flooring and hygiene can impact the development of claw disorders.  The housing facilities are adequate for providing sufficient welfare for the cattle but rubber mats are not used so the cattle are in direct contact with the concrete for a longer time (Figure 18). Both farms recorded bouts of digital dermatitis (Mortellaro Disease). This is associated with dirty, unhygienic flooring and as these farms are not equipped with scrapers and the cleanliness of the floors was observed as being sub-optimal (Figure 15 and 16), these may account for the occurrence of it. If this is the suspected cause of the lameness the animals are isolated immediately to a straw bedded area and treatment sought in order to limit the spread of it. These animals are subjected to antibiotic treatment and foot baths when

leaving and entering the unit for 1 week and the hooves are reassessed to check for the disease. The farmers stated that from experience they have learned that digital dermatitis heels quicker if the animals are removed from the slatted flooring, which correlated with a study from Olmos et al. (2009).

In total these farms had a higher incidence of hoof related lameness the previous farm but the increased walking times and contact with concrete surfaces and hygiene are seen to have an influence on this.

Farm 4 recorded the highest incidence of hoof problems of all 5 farms. On inspection of the facilities it was seen to have varying levels of concrete (Figure 22) that must be negotiated by the cows on route to the milking parlour and the walkways (Figure21) were in a very poor state with areas cracked and broken. This coupled with an impatient employee increased to risk of mechanical stress on the hooves of the cows as they were seen to bunch up at the back of the herd, which leads to the cows rising up their heads and renders then unable to look at the ground to pick placing of their hooves. This may be the cause of the higher number of white line disease on this farm. The entrance to the milking parlour was also at quite a tight angle which requires sharp turning by the cows (Figure 23). Lactation ration is only introduced after calving so they have no time for the rumen to adapt to this, leaving them more susceptible to damage form the environment as the hooves are more sensitive at this time. Olmos et al. (2008) found that abrupt changes in feed trigger the occurrence of sole ulcer white line disease and horn hell erosion so coupling all of these factors together, they can certainly account for the reason the incidence of hoof problems are quite high in this herd. The farmer is aware of this and has plans to improve the surfaces of the main walking areas in a bid to reduce his costs relating to this.

Farm 5 differs from the other farms in that one of the housing facilities has no cubicles and just contains a slatted floor (Figure 25). Even though the cows are rotated this may have a negative impact on the resting time of the cows which can influence the standing times on the concrete for certain periods. As the walkways are in the process of renovation there are a lot of free stones and debris lying around which can increase the amount of mechanical damage to hoof is subjected to (Figure 26). This is the major causative factor for the high level of sole ulcers. At the times of hoof trimming it was noted that those animals that were undergoing routine trimming sowed signs of impact from loose stones like the beginning of bruising on the hoof but no stones were seen to be penetrating the sole itself. This is in agreement with Olmos et al. (2009) whose study

shows that poor quality roadways, long walking distances, narrow/tight angled areas and poor herding skills contribute to the occurrence of lameness in Irish dairy farms. The farmer stated that his incidence of lameness has decreased from 22% last year and hopes that with all the walkways improved and the yard resurfaced that this will decrease further.

As seen from this study the environmental factors do indeed impact the incidence of hoof lesions in dairy herds. The higher incidences of sole hemorrhage/ulcer and white line disease were associated with the mechanical stress imposed on the hoof from the abrasive unyielding concrete and the conditions of the walkways to and from the parlour. As the walkways had to be negotiated twice daily, even small loose debris can impact the hoof health especially around the time of parturition.

Digital dermatitis has been associated with damp, less than hygienic conditions as these provide the perfect environment for harbouring thee pathogen and induce chemical stress on the hoof and aid in the softening of it, this coupled with the contact with the hard surface will lead to poor hoof health. However the incidence of digital dermatitis are seen to improve quicker and have a faster healing time if the affected animals are housed on softer surfaces (straw bedding) once diagnosed.

Horn heel erosion results from both external pressure and the surrounding environment. Dung covered passageways and moist condition provided by slatted housing can increase the occurrence of this lesion.

The results from this study show that the majority of the hoof lesions are recorded when the cows are housed. The housing environment definitely has a negative impact on the occurrence of lameness. In the farms with good maintenance of roadways, the severity of hoof diseases decreases after calving which correlates with the cows being put out to pasture showing that this had a positive influence on the hoof health. O'Driscoll et al. (2009) also found a similar association with pasture grazing of lame cows.

## 6. Conclusion

Lameness and hoof diseases are on-going problems that affect every herd owner in Ireland to some extent. From this study I have seen the impact that the environment in which the cow is living, has on the health status of the hooves. Regardless of the measures put in place lameness and hoof diseases will remain an economic issue as the housing during the winter periods and the walkways from pasture during grazing season are integrated as part of the cow's life as a result of increasing intensity of farming. From this study farm 1 has demonstrated that lameness can be reduced to a low number through improvement and good maintenance of these areas. The other farms are also beginning to improve facilities in order to increase the herd health status of the cows. However as the farms in Ireland are owned by each farmer and their income stems from this business, these improvements take longer to carry out due to the financial burden of this. It is clear to see that the surroundings and the management of the cow, does have an effect on the hoof health. If this is inadequate it can and will increase the incidence of hoof diseases in the herd.

## 7. Acknowledgements

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