PROCEEDINGS

THE FIRST REGIONAL CONFERENCE ON COW COMFORT & LAMENESS

(RCCCL)

10-12 May 2016, Faculty of Veterinary Medicine, University of Tehran, Iran.

IRANIAN VETERINARY SURGERY ASSOCIATION (IVSA)

FACULTY OF VETERINARY MEDICINE, UNIVERSITY OF TEHRAN

The 1st Regional Conference on Cow Comfort and Lameness

10-12 May 2016

University of Tehran, Iran

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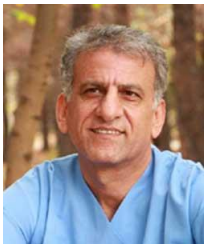

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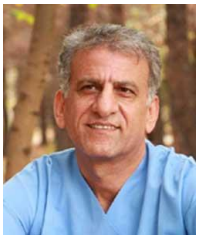

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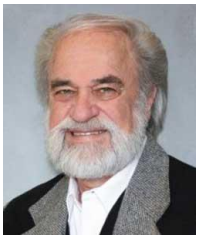

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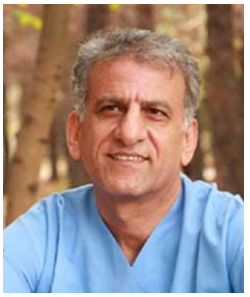

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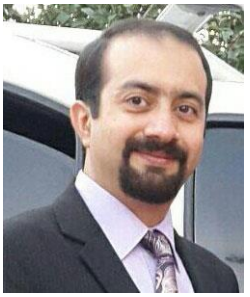

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FOREWORD:

On behalf of the organizing committee it is my great pleasure to welcome you on the first Regional Conference on Cow Comfort and Lameness (RCCCL) which is held by Iranian Veterinary Surgery Association (IVSA) and University of Tehran on 10-12 May 2016 in Veterinary Faculty, University of Tehran, Iran.

Iranian Dairy farming has improved during past 30 years and by the time the average milk production in most provinces increased up to 40 kg/ day. On the other hand, the size of dairy herds is steadily growing. Cow comfort is important factor to reach to high production values in modern dairy industry. There are a lot of factors which can play significant role in cow comfort, such as heat stress, bedding, walking alleys, milking procedures, fly control and specially hoof care and lameness. Modern techniques in management of hoof care, bedding, control of heat stress and fly control are practicing in modern dairy farming in Iran. We believe that our developing dairy farming needs to know more about the new scientific approaches and technologies. Lameness as a part of orthopedic sciences has a special place in Iranian Veterinary Surgery Association and many specialists are working on different aspects of lameness in dairy cows and horses.

It is an honor for the organizers to have speakers and participants from ten different countries (Canada, England, New Zealand, USA, Holland, Turkey, Jordan, Australia, Kazakhstan, and Iran) in this conference. This was done by constant works in scientific and organizing committees. I wish to extend my gratitude to them for their follow up and efforts that lead to this event. It is obvious that organizing such an event is not possible unless a national cooperation between Scientists, Commercial companies and Dairy industries. I want to kindly forward my sincere thanks to our sponsors (Sanadampars and Yasnamehr group as gold sponsor, Daminteb and Ceva as Silver sponsors) for their support and help. I should appreciate the authorities of Faculty of Veterinary Medicine, University of Tehran which, without their kind contribution, we could not organize this event and especially I would like to express my gratitude to Dr. Vojgani (Dean) and Dr. Sharifi (vice associate dean for research) of the Veterinary Faculty.

Our young generation (students and young colleagues) has always accompanied us and once again they have been doing lots of works in this event. Many thanks to Ms. Fahimeh Mohamadi as the secretariat of this meeting and Ms. Shahrzad Farhbodfard and the student organizing committee that have done excellent job in helping us to organize this event.

I hope all participants enjoy the scientific excellence of this conference and have very pleasant stay in Tehran. I also hope our international guests take pleasure of very beautiful and fantastic touristic attractions of Iran. I wish this event can make a good media for all participants in future contact and sharing new ideas.

Sincerely yours

Ahmadreza Mohamadnia. DVM., DVSc.

President of RCCCL and IVSA

COW COMFORT & CATTLE LAMENESS
"AN ONGOING THOUGHTS AND CHALLENGES"

Welcome to the 1st. Regional Conference of Cow Comfort and Cattle Lameness, Tehran, Iran, kindly sponsored by Sanadam Pars, Ceva Pars and Daminteb companies. Without their generous supports this scientific gathering would not be possible. Experience tells me that attending conference or symposium is about much more than obtaining continuing education, professionally it provides a great opportunity for you to meet other expertise and specialists. These contacts can lead to partnership, mentoring, business exchanges, sharing information and career opportunities. In this regard I am most pleased to welcome to all of you and to extend my heartfelt appreciation to the distinguished keynote speakers and experts whom accept our invitation to come from USA, Canada, England and Newzeland not only present the newest information available in all aspects of cow comfort and cattle lameness, but organizing workshops with panel discussion which I personally think they will succeed masterfully. The words "Thank You "are not sufficient as an expression of our gratitude for their generosity.

It appears without saying that of all the clinical areas in dairy farming lameness goes largely underestimated if not unrecognized. Nowadays, globally recognized that it is a major issue both from the standpoint of economic losses to decrease production but also presents a serious animal welfare issue (feeling, biological functioning, natural living) .The paradox of modern animal agriculture is that many of the husbandry practices intended to enhance performance and also enhance predisposition for damaged hooves and infectious hoof disease transmission (Jenifer H Wilson Welden 2015). Milk yield reduction, reduced feed intake, weight loss, reduced fertility and premature culling of affected animals are the most problems. Time budgets are the most determinants for assessing the cow comfort index in commercial free stall herds. The index witch insure longevity of a cow and the length of her productive life. Therefore as Sotirios Karvountzis Diploma Cattle Hoof Care commented in Veterinary Times we need to be able to distinguish between fact and fiction. Otherwise "Cows are not lame, they are just hobbling on three feet". So, we can look at the role of the mobility scorers, professional hoof trimmers and vet in investigating this condition and how to services we think improving cow welfare and longevity by improving hoof health requires dedication and careful management decision-making, but it is possible by positive thinking ,rational and comprehensively based on the best science we have. It is worth to add the two biosecurity comprises, namely bioexclusion and biocontainment when we face to strategy of management practices to prevent the introduction of diseases and pathogens to an operation and to control spread within the operation as far as infectious lameness is concerned.

To this end,I hope our attempts at this meetings can bring out more the clinical ambiguities , the diagnostic alternatives, evidential inconsistencies together withhold the source of the trouble , as it is withheld the investigator himself, until it is discovered the evidence. On final word, inspiration of the idea for having' such event on cattle lameness in this geographical region of the world "Middle East" by Ahmadreza Mohammadnia associate professor and president of IVSA is greatly acknowledged. Our sincere gratitude also goes to Dr.Fahimeh Mohammadi who spent many long hours preparing things for today. Her patience and willingness "To get every things" right are much appreciated and last not least "assume nothing and question everything"

Best

Iradj Nowrouzian, DVM., MPVM.

Professor and scientific chair of 1st RCCCL

Tehran, Iran 10 to 12 of May, 2016

Our warmest welcome to our precious audience who gave us the honor of attending the “The 1st Regional Conference on Cow Comfort and Lameness” and would like to take their deepest consideration to the most important factors on productivity, health and welfare.

- Intensive herds, non – grazing farming, high production and heat stress are farming characteristic in Middle East. These characters impact animal health, welfare and farm economy.
- Demands for improving feed conversion rate and high production level conduct researchers and managers to focus more on animal health and welfare.
- Lameness control and cow comfort are important issues of new production management.
- We hope this conference will cover our regional farmers’ and scientists’ demands.
- This conference is conducted by Iranian Veterinary Surgery Association (IVSA).
- Very special thanks dedicated to a group of dear colleagues, Prof. Iraj Noroozian, Dr. Ahmadreza Mohamadnia and other members of organizing committee whom this conference is conducted by their efforts.
- Also, special thanks dedicated to our respectful sponsors Sanadam Pars, Damin Teb and Ceva.
- We would like to thank our great lecturers Jan Shearer, Richard Laven, Helen R Whay, Arturo Gomez, Daniel Weary, Marina Von Keyserlignk, Shahb Ranjbar who accepted our invitation and gave very sophisticated lectures for this conference.

We hope that our audience and our guests will enjoy the scientific program and their stay in Iran.

Dr. Arya Badiei (DVM., DVSc.)

Chair of the Organizing Committee of the 1st RCCCL

Contents:

Effects of heat stress on milk production, fertility and health of dairy cows in Tehran province, IRAN

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Cow comfort is one of the most important aspects in herd management economy as it raises animal life span and feed conversion rate and also lower the risk of health problems.

Heat stress is a very big issue which disturbs cow comfort as in many countries like Iran, there are more than 5-7 months per year in which heat stress is a critical issue.

The objective of this paper has been analyzing heat stress impact on health, production and reproduction status of Iranian farms. The negative effects of heat stress were calculated in 21 Farms and 41291 cows in different parities, in Tehran province.

We compared service rate, conception rate, pregnancy rate, average days in milk, culling rate, production level in different parity and different days in milk, dry matter intake and still birth rate in winter and summer.

The obtained results showed the significant difference in conception rate, pregnancy rate, and average days in milk and milk production in different days in milk in first parity except in cows less than 40 days in milk. In second and third parity, there was a significant difference in production level in less than 200 days in milk

Heat stress is characterized by elevated respiration rates and rectal temperatures, and has been implicontents in impaired metabolism (Bandaranayaka and Ban- Holmes, 1976),

Temperature-humidity index (THI), which uses dry bulb temperature (Tdb) and wet bulb temperature, was initially developed by Thom (1959) as a heat index for human comfort but it remained the most common heat stress indicator used until now for different animal species.

Lactating dairy cows prefer ambient temperatures of between 5 and 25 8C, the ‘thermoneutral’ zone THI 50-72 (Roenfeldt, 1998).

Lactating dairy cows create a large quantity of metabolic heat and accumulate additional heat from radiant energy. Heat production and accumulation, coupled with compromised cooling capability because of environmental conditions, causes heat load in the cow to increase to the point that body temperature rises, intake declines and ultimately the cow’s productivity declines.

Environmental factors such as temperature, relative humidity, solar radiation, and air movement and their interactions often limit the performance of dairy cows (West, 2003)

Heat stress has a variety of negative effects on physiology and health status of animal's life stages.

Many studies show that heat stress decreases uterine blood flow (Oakes et al., 1976), placental weight (Alexander and Williams, 1971), and birth weight of the offspring (Collier et al., 1982; Tao et al., 2012a), which suggests compromised fetal growth.

Heat stress during the last 6 wk. of gestation negatively affects the ability of the calf to acquire passive immunity, regardless of colostrum source. No differences were observed in the amount of colostrum produced ($P = 0.52$), mean IgG concentration in colostrum ($P = 0.46$), or total IgG produced ($P = 0.54$) by cows from each treatment group at the first milking (Monteiro)

Heat stress during the dry period impairs cows' immune function (do Amaral et al., 2011) and leads to a greater disease incidence in the postpartum period (Thompson and Dahl, 2012). Heat stress during gestation also has adverse effects on the offspring.

Summer heat stress is a major contributing factor in low fertility among lactating dairy cows. It is a worldwide problem, which inflicts heavy economic losses and affects about 60% of the world cattle population. Conception rates drop from about 40–60% in cooler months to 10–20% or lower in summer, depending on the severity of the thermal stress (Cavestany et al., 1985).

HS-induced alterations in follicular dynamics (_Wolfenson et al., 1995) the lack of a decline in the number of medium-size follicles during the period of dominance of the first-wave (Badinga et al., 1993).or preovulatory follicle (Wolfenson et al., 1995)

Exposure of cattle to thermal stress does not suppress the overall pattern of follicular wave dynamics in cattle. However, HS does suppress follicular dominance, resulting in a number of changes in follicular growth. Among them, at least two responses standout in their physiological importance: 1. development of a larger number of large follicles probably increases the rate of double ovulation and hence of twin calving; and 2. early emergence of the preovulatory follicle lengthens the dominance period, and this has been shown to be associated with lower fertility in spontaneously cyclic dairy cows (Bleach et al., 1998).

Studies indicated that plasma estradiol concentration was lowered during HS. Lactating cows and dairy heifers that were heat-stressed during the second half of the cycle (Wilson et al., 1998) or during the entire cycle(Roth, 1998) had a reduced preovulatory surge in plasma estradiol concentration.

Chronic exposure to summer HS suppressed progesterone production, Various aspects of the effects of HS on oocyte quality and embryonic development include the following: 1. the deleterious effects of heat exposure during different stages of oocyte maturation and early embryo

development, on the impaired function of oocytes and embryos, in both in vitro and in vivo systems; 2. the increase in the heat tolerance of the embryo with age; _3. The production of heat-shock proteins by the embryo, and their potential function in protecting the embryo during HS; and _4. The possible use of antioxidants to increase embryo resistance to thermal stress (Wolfenson et al., 2000)

A milk yield decline between 0.08 and 0.26 kg for each unit increase in THI unit was found (Brügemann et al. 2012).

A decrease in milk yield of 21% when the THI increased from 68 to 78 is reported. For THI values above 69, the milk yield decreased by 0.41 kg/d per cow and THI unit increase. This decrease in milk yield of heat-stressed cows may be explained mainly by a lower DMI and a lower conversion efficiency of feed into milk (kg of FCM/kg of DMI)(Bouraoui et al. 2002) .

In a study conducted in the United States, the milk yield decreased by 0.23 to 0.59 kg per THI unit per day (Bohmanova et al., 2007).

Another important factor influencing the effects of heat stress on milk production is the stage of lactation. a greater decrease in early lactation than in mid or in late lactation is reported (Novak et al. 2009) . They mentioned that cows in early lactation are more sensitive to the effect of heat than cows in late lactation.

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The comparison of hoof dry content in different parities, seasons and stage of lactation

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Abstract:

There are many reasons for lameness and especially laminitis in dairy herds. These reasons mostly related to cow comfort indices, time budgeting, nutritional factors and etc.

There is a relationship between infectious causes of lameness like Digital Dermatitis or Interdigital Necrobacillosis (Phlegmon), and wetness and moisture condition of the barns and environment.

There are always doubt about the relationship between wet condition and hoof horn related diseases. There are many published data about the effect of wet condition on hoof horn in abattoir materials. These include dryness, moisture content, elasticity and other aspects of different places in hoof horn.

The object of our study was to determine dry content of hoof horn in live cows. We selected 60 dairy cows in a large and high producing dairy farm with over 3000 dairy cows in 4 different groups. Each group consisted of 15 cows.

1st lactation, 2nd lactation, 3rd lactation and 4th and over.

We began our study in winter 2014 in three different issues:

1) If there is any differences in dry content of hoof horn in these 4 lactational groups in fore and hind claws?
2) If there is any differences in dry content in fore and hind claws in four seasons of the year?
3) If there is any differences in dry content in fore and hind claws in different DIM?

We concluded that, the dry content of fore claws in 1st lactation dairy cows was significantly higher than the 2nd, 3rd& 4th and higher.

The dry content of hind claws was higher in 1st lactation compare to the 3rd and the 2nd lactation compare to the 3rd lactation.

The results of the seasonal effect on dry content showed that the claws in both limbs are dryer in spring and summer.

We analyzed the effect of DIM on dry content of hoof claws in 6 different stages on a 60 days interval from the beginning of lactation and revealed that the dry content of claws was at the lowest level after parturition. It will go up till the end of the 4th. Stage (day 240) and then it doesn't have any significant changes.

To compare these 3 different items in a single model and rolling out the non- effective item, s, we used the GLM (general linear model multivariable) at the end of this analysis, and concluded that, the parity and seasons have the most effective role on the dry content of hoof.
So, when we are talking about the factors that can cause laminitis, we should consider the effect and the role of dry and moisture content of hoof claws. Maybe the wetness of barns makes the hoof claws more vulnerable to the environmental insults. These factors should be considered more in some critical period like after parturition or in the higher producing dairy cows especially in higher ages when they can produce more milk and are more beneficial.

Key words: Laminitis, Dry content, stage of lactation, seasons, parity

Digital Dermatitis: Successful Management

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Around the world, even in well-managed dairies, there's a good chance digital dermatitis (DD) is present. It is highly contagious, and if left unchecked, can cause painful ulcerations that often lead to lameness. Common practices for controlling DD have been limited to footbaths and topical treatment of severe lesions, with no clearly established guidelines for optimal management. Many dairy producers might be surprised to learn that DD can be effectively controlled, but it requires a slightly more sophisticated and long-term approach than the current standard of care. This article explores the tools already available that can be used on a dairy to bring DD prevalence under control.

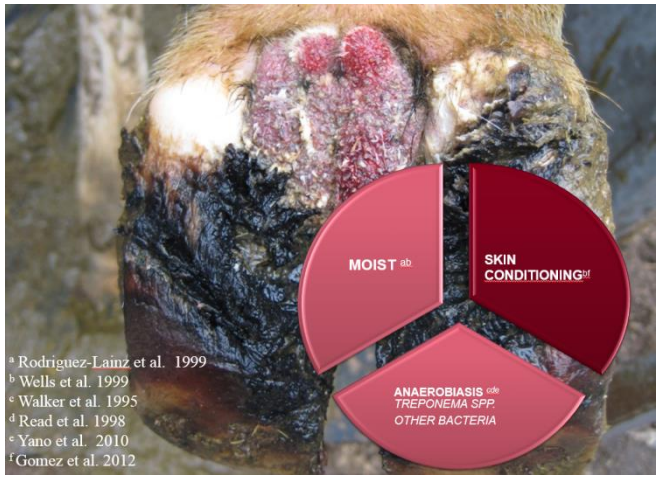

Figure 1. Digital dermatitis etiologic components.

The first step in controlling DD is to understand both the epidemiology, as well as changes in prevalence of the disease. Digital dermatitis is multifactorial, with a strong bacterial component, namely Treponema spp., which can exist in both active and cystic (dormant) forms. In fact, DD causes changes in the shape and structure of an infected hoof before any lameness symptoms are observed, such as increased heel height, claw angle and heel horn erosion.

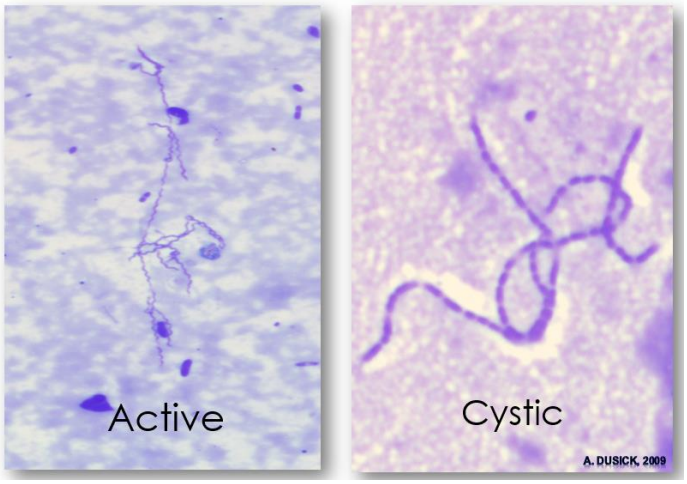

Figure 2. Active and cystic forms of Treponema spp.

Once the disease has infected the animal, it can persist as a problem throughout the animal's life. It is important, therefore, to focus on minimizing new infections and decreasing the duration of acute (ulcerative) M2 cases. In order to achieve this, we rely on a set of tools available called "FIGHTERS", which stands for:

- Footbath
- Infection Status
- Group of Animals
- Hygiene
- Trimming
- Early Topical Treatment
- Record Keeping
- Skin Quality - Skin Protection

Here's a breakdown of the FIGHTERS strategy (Figure 1) for controlling digital dermatitis.

Footbath:

- The design of the footbath is of paramount importance to maximize the application of disinfectant solutions, decrease the amount of water used and minimize the amount of waste chemicals dumped into the environment (and save money!). Chemicals should always be used according to their labels. An ideal footbath is 3.0 to 3.7 meters long, 0.5 to 0.6 meters wide, with a 28 cm step-in curb and a 10 cm minimum solution depth. Sloped sides (70°) 1 meter high also help save solution and maintain adequate solution depth.

- The main objective of the footbath is to control early (subclinical) and chronic lesions, avoiding the progression of these lesions into acute (ulcerative) stages. Footbaths are not a substitute for individual treatment of acute lesions.

- The appropriate frequency of footbath applications should be determined based on infection rate, as well as foot and leg hygiene scores for

each individual farm.

Figure 3. Different footbath models showing solid sides, more than 3.5 meters in length and <60 cm in width.

Infection Status:

• Assessing disease prevalence is the first step to quantifying the extent of the problem. The next step is evaluating infection status. Topical treatment applications need to be performed based on active surveillance. Some tools such as "DD Pen Walks," DD diagnosis in the parlor, or serologic identification of active DD cases can be used to directly evaluate DD status before lameness symptoms and chronic stages show in animals affected with the disease.

Group of Animals:

• The rearing period is a crucial factor in herd prevalence of this disease. Success of the milking herd DD prevention program will be determined by the quality of DD prevention during the rearing period. A recent research study we conducted at the University of Wisconsin (under the direction of Dr. Dorte Dopfer), USA, showed that ~67% of the heifers that were initially infected with DD during the rearing period experienced a case of DD during first lactation. However, animals kept disease-free (during the rearing period) only experienced a case of DD during first lactation in 13% of the cases. In addition, reproductive, production and lameness performance during the

first lactation was significantly affected by the occurrence of DD during the rearing period.

• Precise identification of high-risk groups of animals can be achieved by evaluating the DD incidence and prevalence by days-in-milk or by lactation group. This is required in order to maximize the resources and efficiency of control programs during the rearing period and in adult cows.

Figure 4. Digital dermatitis lesion in a 7 month-old Holstein heifer.

Hygiene:

• Digital dermatitis infection is associated with poor hygiene. The correlation between dirty environments and higher DD prevalence is widely accepted. However, even in fairly clean barns, special attention needs to be made to critical points where disease transmission can happen, even if animals are exposed to problematic spots for very short periods of time. Some examples are when animals 1) walk through footbaths full of manure during periods when footbaths are not actively used, 2) are confined to small spaces to facilitate pen cleaning activities, 3) are exposed to manure piles dragged across alleys by scrapers or, (4) walk through unhygienic surfaces located around water troughs.

Trimming:

• Appropriate trimming can help prevent and treat DD infections. Routine trimming of feet allows for close examination, in addition to early identification and treatment of DD infections. Prevention can be achieved by removal of loose horn at the heels, wide trimming of the axial space of the lateral toe and treatment of DD lesions found during trimming (such as necrosis of the toe).

• Comprehensive trimming/foot examination programs should always take into consideration non-lactating cows, such as replacement heifers and dry cows.

Early Topical Treatment:

• Bacterial colonization of the deeper epidermal layers of skin is observed at very early stages of the disease. Over time, skin proliferation can increase as the animal reacts to the disease. Therefore, deep colonization and thickened skin, the natural disease progression, compromise treatment success and are exacerbated when lesion treatment is delayed. Consequences of delayed treatment include increased lesion recurrence, proliferation of skin and transmission of DD to healthy animals. Only programs that include active surveillance to detect and topically treat new cases of the disease as early as possible will achieve long-term success. A farm goal of 0% presence of skin proliferation in M2 lesions at treatment can be established to recognize and monitor early treatment.

• The objective of early topical treatment is to reduce infectious period duration of DD lesions and increase cure rates. The only solution to reduce the number of active DD lesions is topical treatment. A one to three week follow up of the initial DD lesion treatment must be included in the treatment protocol. Although research efforts are being made to find non-antibiotic topical treatments, Oxytetracycline (OTC) is still an effective option to treat M2 DD cases. However, working along with your veterinarian is advised when using OTC products.

Record Keeping:

• The increasingly common use of on-farm management software allows for recording health events, including lameness and hoof lesions aimed at organizing future tasks (e.g., monthly number of calvings, animal movements, etc.). These records can help determine severity and prevalence of DD infections in different groups of animals, and thus the intensity of DD control programs in specific groups of animals can be modified accordingly.

Skin Quality – Skin Protection:

• Digital dermatitis develops from multiple risk factors as a result of a weakening of the skin barrier, due to mechanical irritation and wet conditions. Improving skin integrity and/or enhancing immune response in the presence of bacteria (including Treponema species) that cause the disease will help provide a barrier of protection against the disease. One way to enhance disease resistance is to provide cattle with an adequate supply of effective trace minerals, which have been shown to play a critical role in wound healing, as well as maintaining the heath and integrity of skin.

• Research has shown supplementing pre-calving heifers with complexed trace minerals helps improve skin recovery from subclinical DD infection and maximize the resources needed by the immune system to fight infections. An obvious advantage is the possibility of decreasing DD prevalence by more than 50% even when the use of footbaths and topical treatment is limited or in cattle that are not easily handled on a regular basis such as pastured cattle and beef cattle in large feedlots.

ACTION	TOOLS	OBJECTIVE
FootBath	Dimensions, Chemicals	Decrease Chronics/Subclinical going to Acute DD
Infection Status	Elisa, Visual Inspection (Chute, Parlor), DD Pen Walks	Early Detection; Monitor Cure
Group of Animals	Tailored Interventions Periods Of High Risk Heifers	Maximize Work Efficiency and DD Control Success
Hygiene	Focus On Critical Control Points	Decrease Risk of Transmission
Trimming	Professional Trimming	Prevention And Cure
Early Topical Treatment	Topical (Wrap) Treatment of M2 DD	Maximize Clinical Cure – Minimize Skin Proliferation
Record Keeping	Commercial Software	Monitor and Adapt Management
Skin Quality – Skin Protection	Complexed Trace Minerals	Maximize Skin Integrity- Skin Protection

Figure 1: Summary of FIGHTERS against Digital Dermatitis

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Modern Hoof Care Management

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Abstract:
Lameness remains one of the leading causes of lost efficiency in cattle production systems. Furthermore, losses attributed to decreased reproductive and udder health performance are likely associated with initial hoof health problems that are not usually considered. Hoof care programs, involving interventions such as lameness detection, preventive and therapeutic hoof trimming or nutritional strategies are commonplace in well-developed dairy industries, but certainly inconsistently applied around the globe.
The objective of this abstract is to review the current standard hoof health programs, evaluate the background history that justifies the basis for these programs and justify a more sophisticated approach to maximize hoof health in dairy herds.

Current Hoof Health Programs. Lameness detection remains one of the pending subjects in even well run dairies. Traditionally, the prevalence of lameness has been evaluated based on visual assessment of locomotion. Unfortunately, given its subjective nature (Silva del Rio et al., ADSA-ASAS, 2015), the precision of lameness detection remains conditioned to the experience of the observer (Fabian et al, 2012) and the compliance with a systematic approach.

Lesion records have been also used to evaluate the hoof health status in the herd, sometimes as a complementary piece of information to locomotion assessment. Traditionally, lesion records have been stored in paper, with obvious limitations for their use and analysis, or in farm softwares that, although made their management easier, lacked standardization within and between farms. The industry has shown however this to be an actively developing area with the surge of multiple digital platforms serving as data recording and management tools, mainly used by professional hoof trimmers and less frequently used to modify farm level hoof health programs.

In general, and strongly dependent on the different production systems (pasture, freestalls, open lots, farm size…), cows have been recommended to be functionally trimmed at dry-off and at mid lactation (around 150 d). Variations in trimming schedules between the rearing systems have been primarily based on differences in hoof horn development, overall hoof health and the extent of the trimming "culture" in a given country. As expected, a wide distribution of lameness prevalence has been reported across production systems and regions. In example, Cook et al. (2003) reported a lameness prevalence of around 11% in the best 25th percentile of 30 farms surveyed in Wisconsin, and Von Keyserlingk et al. (2012), reported large differences between various regions in Canada and the US with alarming lameness prevalence ranging from ~30% to >50% of the herd.

The reality is that about one half of the adult cows visiting the trimming chute show some type of foot lesions in well-developed dairy industries where the cows are mainly kept in confinement (The Alberta Dairy Hoof Health Project, 2012). Specifically for the type of lesions, digital dermatitis represents 50% of them. When dealing with replacement heifers, the total percentage of animals with lesions is certainly less (~15%), and digital dermatitis is by far the most common lesion found (NAHMS, 2007).

History of hoof health management programs. The understanding of lameness in cattle has fundamentally evolved over the years. The initial systematic approach to foot problems was laid out by Toussaint Raven (1985) from a biomechanics perspective. The cow's anatomy and the natural progression from heifer to milk production defined the conditions that predisposed the animal to suffer from imbalanced hoof growth and therefore for the occurrence of lameness.

Years later, hand in hand with the improvements in nutrition and subsequently in milk production, much of the attention was diverted to the metabolic etiopathology of lameness problems. Subacute ruminal acidosis and the consequent inflammation of the hoof laminae became took the responsibility of how we understood lameness. However, much of the ideas about "laminitis" were brought by robust research developed in the horse hoof. Many of the trials trying to replicate "laminitis" in cows through changes in rumen conditions failed to reproduce the typical lameness observed in the field, and much of the pattern in seasonal non-infectious lesions remained unexplained by simply using the "metabolic perspective".

During the last decade, much of the attention shifted then to the study of the relationship between the cow and the environment as a determinant of lameness problems. The distribution of the different activities the cows do during the day, or so called timebudgets, and the interaction with different walking and resting surfaces was the subject of extensive research that really shed a lot of light on the understanding of the problem. Specific lines of research looking at the anatomy of the protective hoof fat pad and the relationship with body condition score, the traumatic origin of lameness due to suboptimal walking surfaces, the influence of social competition or the physiology around parturition and aspects of bone and epithelial development lead to recently concluding that lameness is likely a response to an inflammatory state of multiple origin (Newsome et al., 2016).

Modern approach and solutions to modern hoof health problems. Successfully managing hoof health requires the consideration of the different perspectives indicated above. Prompt detection of lameness, establishment of a correct trimming technique, trimming schedules and the evaluation of trimming records, adequate hygiene and use of well-designed footbaths, consideration of the timebudgets, precise nutrition and properly built transit surfaces are the factors to be managed in any hoof health program.

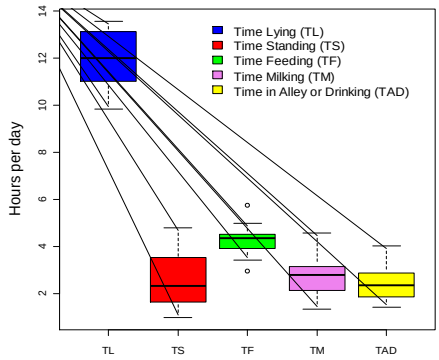

Figure 1. Timebudget of dairy cows (Gomez and Cook, 2010).

1. Lameness Detection: We acknowledge the benefits of systematically evaluating the locomotion status of the herd. The correct evaluation of the distribution of lameness severity across lactations and days in milk, can be used to have an approximate estimation of the losses in production performance, easily translated to marginal lost revenue. However, from a practical stand point, the goal in the farm should be, in my opinion, to have a simple and sensitive method of detecting lameness promptly. In example, if the 5-point locomotion scoring system is used, ONLY the locomotion 3 would be the real focus of an intervention or lameness detection, implying zero percent allowance for score 5 and 4. As importantly, the allocation of resources and compliance with the protocol aimed at finding locomotion 3 cows can make a difference on the final success.
2. Correct Trimming Technique: Very well-known is the fact that >90% of the lesions occur in the lateral toes of the rear legs. Only in a few specific cases lameness problems are more prevalent in the front legs. The gold standard trimming method ("Dutch method") was defined by Toussaint Raven three decades ago and still used by most of the professional trimmers. Other methods have been also described (Kansas method, white line method,…) but their use is less extended. Over time, trimmers and hoof specialists using the "Dutch method" have been putting a lot of attention on the rear lateral toe's care due to the higher proportion of lesions found in this toe but unfortunately, the recommendations on how to trim the medial toe have been "relaxed" a little bit. Although it has been originally described that the dimensions of the medial toe could serve as a reference to trim the lateral toe (its growth and wear are most of the times correct), it is not uncommon to see many professional trimmers removing more hoof horn than needed from this toe. The conscious review and eventually correction of the trimming technique is a fundamental part of a successful

hoof health program and as herds become larger the sensitivity to over- or under-trimming becomes more important.

Figure 2.Correctly trimmed foot according to the Dutch method.

3. Trimming schedules: The common approach in many farms with an organized trimming program is to trim cows at dry-off and mid lactation (~150 DIM). This schedule meets the needs of correcting any problem during the dry-off period as cows would be "resting" until calving, and there is a good opportunity to recover. The mid lactation trim at 150 DIM, however, might not be the most recommended practice. For each farm a careful study of the records/problems could help to establish the most appropriate moment to perform a trimming during the lactation. My recommendation would be to adapt the trimming, taking into consideration changes in management or environmental conditions overtime and, in general, perform a trimming during the lactation about two months before the median time of the main lesions occurrence.

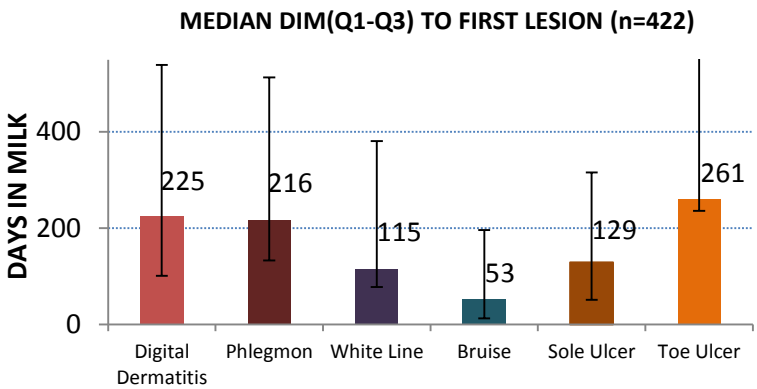

Figure 3.Distribution of time of lesion diagnosis by DIM in a 1000-cow dairy in Wisconsin.

4. Adequate hygiene and appropriate use and designed footbaths: Infectious problems are a function of infectious and environmental pressure and skin quality. Digital dermatitis is the most common hoof infectious lesion in cattle. During the meeting there would be extensive coverage of the topic and, from a practical stand point, I would like to refer to the abstract "Digital dermatitis: successful control".
5. Timebudgets and transit surfaces. Lying time can be used as a marker of cow comfort in confined dairy cattle. In relation to lameness, the influence of milking time, defined by the management practices and the design of the facilities, has been correlated with changes in behavior in lame animals, primarily modifying lying time. The relationship between lying behavior and the lying surfaces has been as well strongly associated with lameness events. Similarly, the transit surfaces have been shown to be one of the more significant risk factors for lameness.
The traditional approach to hoof health has been based on the adaptation of the management to the facilities. Given the importance of hoof health in the overall farm sustainability, new facilities are today designed and built taking into consideration the timebudgets to minimize, between others, hoof health problems.

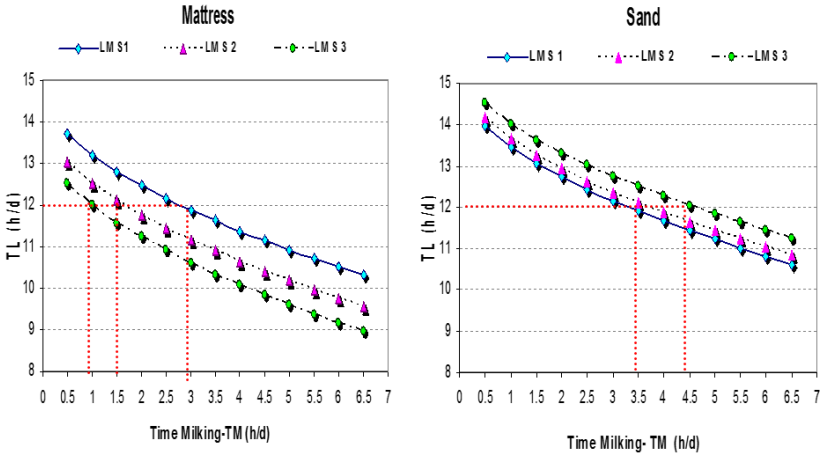

Figure 4. Differences in lying time (TL) between lame (LMS 3) and healthy (LMS 1, 2) cows by type of freestall base (Sand or Mattress) and milking time (TM).

6. Nutrition. Nutrition has evolved considerably in the last decades and so milk production. We have better mastered the science of feeding cows to improve efficiency, minimizing digestive upsets. However, the best producing cows remain still in higher risk of lameness. We have also learnt that by using new feeding technologies we can better meet the needs for milk production, reproduction but also for hoof health growth, skin

quality and decreased local or systemic inflammation. A relevant technology that has given good results when included in hoof health programs has been the correct supply of trace mineral nutrition. Organic compounds where the trace metals are linked to an aminoacid have given an advantage to hoof health and facilitated the implementation of successful hoof health programs.

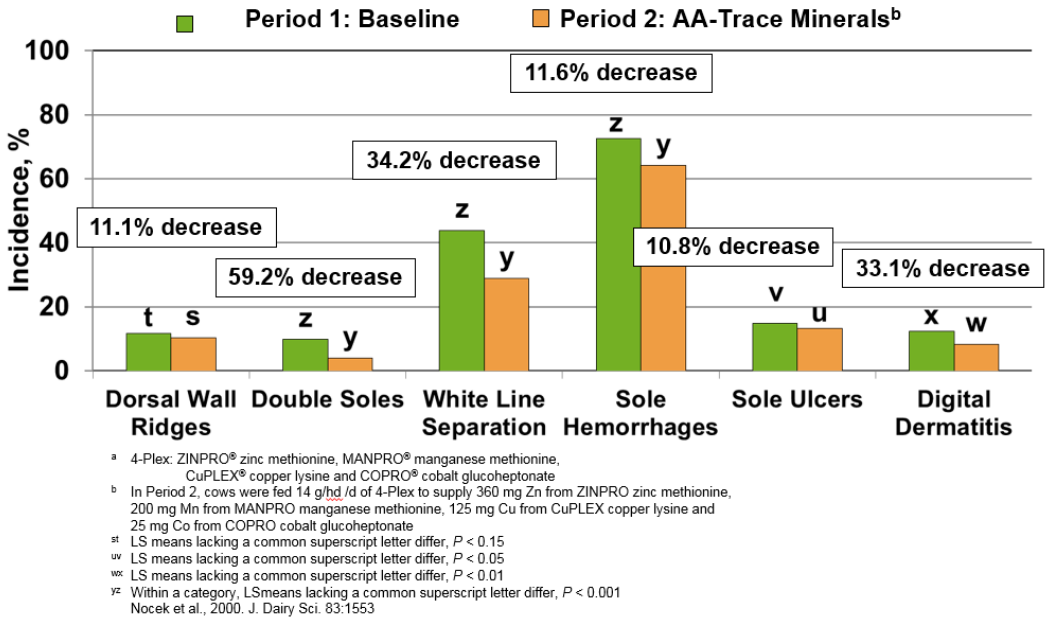

Figure 5. Effects of feeding aminoacid trace mineral complexes in comparison with the traditional inorganic forms on hoof lesion prevention (Nocek et al., 2000).

Farm profitability is certainly limited by suboptimal hoof health. Additionally, lameness is likely the best marker of animal welfare and one of the main arguments that the general public used to judge modern farming. Lameness prevention is a must today and requires of a sophisticated approach according to the extraordinary capacity of our animals.

Let's make happy cows!

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Development of claw horn lesions- How do they start and where do they end up?

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Lameness is the most important cause of poor welfare in dairy cattle; in addition, along with mastitis and poor fertility, it is one of the three most economically important diseases in dairy cattle.

In dairy cattle ~90% of lameness arises in the hoof. Lameness in the hoof can be divided into two categories – i) infectious lameness (principally foot rot (interdigital necrobacillosis) and digital dermatitis and ii) non-infectious lameness; i.e. claw-horn diseases such as white line disease and sole ulcer. Treatment of infectious diseases is simple and generally effective, although control, particularly of digital dermatitis, can be difficult to achieve. In contrast treatment of claw horn disease is palliative at best, focussed as it is on removing the damaged horn and reducing weight bearing on the affected site. Treatment does not restore normal hoof anatomy or repair the damage done to the horn-producing tissue. Therefore cows which have been treated for claw-horn disease remain at significantly increased risk of recurrence of such disease in both the affected foot and in the contralateral limb. A further difference between infectious lameness and claw-horn disease is the level of pain and discomfort; this is much greater and more prolonged in animals with claw-horn disease than animals with foot rot or digital dermatitis. Additionally, the pain and discomfort associated with claw-horn disease begins significantly before lameness is detected, in contrast for cattle affected by infectious disease there is a very short interval between the onset of significant pain and the onset of clinical disease.

To understand why this is the case we need to know how claw horn lesions develop and the subsequent effects of those lesions on the hoof and the subsequent risk of claw-horn disease.

Starting at the beginning

The most important risk factor for claw-horn disease is calving. In a landmark series of papers the University of Bristol group showed that the changes in ligaments which were an essential part of the preparation also had significant effects on the connective tissue of the hoof suspensory apparatus. In heifers, Tarlton et al (2002) demonstrated that biochemical and histological changes occurred within the suspensory apparatus of the hooves around the time of first calving, and it was likely that these changes were mediated by metalloproteinases (MMP), whose function is to degrade collagen. The Bristol group linked their findings with those of Lischer et al (2002) who showed that increased laxity of the connective tissue of the suspensory apparatus of the distal phalanx was a consistent finding prior to the development of sole ulcers. They hypothesised that the changes they

found in association with parturition were therefore the start or trigger for the development of claw-horn disease.

In a subsequent study by the Bristol group (Knott et al 2007); they confirmed the biochemical and histological changes they had seen in the earlier study and also showed that housing heifers in cubicles rather than straw yards also impaired the biomechanical resilience of the hoof. The effects of housing and parturition were additive, so the changes seen in parturient heifers kept in cubicles were greater than the changes seen in non-pregnant heifers kept in cubicles. The hypothesis, therefore, is that the initial changes seen in the development of claw horn disease are due to a combination of the effects of parturition with other stresses, especially housing, and that it requires both stressors to be present for the initial corium damage to occur. This was supported by the sole haemorrhage data reported by Knott et al (2007), which showed that significant sole haemorrhages were only seen in heifers that had calved, but also that haemorrhages in cubicle housed lactating heifers were significantly worse than those on lactating heifers housed in straw yards (see Table 1).

Table 5
Effects of housing, diet and parturition on histology of the laminae

House	Group	Width	Angle	Irregularity
Yard	YLP	18.11	1.44	3.08
	YMP	15.73	1.08	2.69
	YMF	14.89	1.22	2.55
Cubicles	CLP	14.75	2.55	1.91
	CMP	14.65	2.06	2.00
	CMF	15.23	1.68	2.08
Significance	House	0.027	<0.0001	<0.0001
	Diet	*0.79*	*0.74*	*0.96*
	Lactation	*0.17*	0.006	*0.37*

Non-significant *P* values are indicated in italics; for explanation of units see text.

Table 1: From Knott et al (2007)

This hypothesis is further supported by data from a longitudinal study where heifers were reared on cubicles from mating until calving and then transferred to another cubicle yard (Laven and Livesey 2002). Significant hoof horn haemorrhages were not seen in those heifers during the rearing period but after calving there was a significant increase in haemorrhages even though the heifers had spent more than 9 months in the cubicle yard before calving.

What is the initiating factor?

It is the laxity of the supporting tissues which produces the damage to the corium which then is seen as haemorrhages, and, if the damage, is severe enough white line disease, sole ulcer and other claw-horn diseases.

This hypothesis was described by Christoph Lischer as the 'tourist in a hammock'. As illustrated in Fig. 1, movement of the distal phalanx can lead to the damage of the corium (the horn-producing tissue), either the corium of the white line or the corium of the sole (or both).

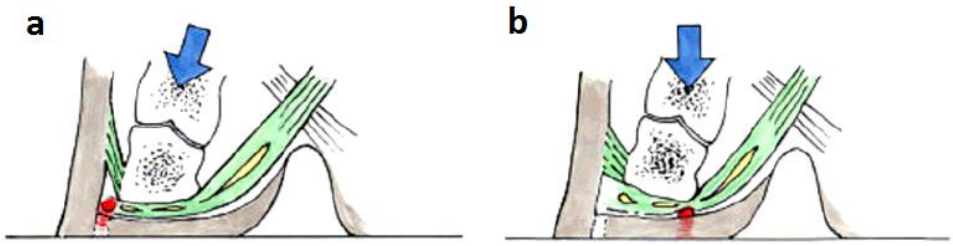

Fig 1: Diagrammatic illustration of how laxity in the supporting structures of the distal phalanx can produce damage to the corium and subsequently haemorrhages which become apparent on the palmar/plantar surface of the hoof (a – white line; b- sole) (from Lischer and Ossent 2002).

The analogy with a hammock illustrates clearly how calving and other stressors, such as housing interact to produce significant corium damage (se Fig. 2), with the wind blowing through the palm trees being analogous to the concussive forces which occur when cows are housed on concrete.

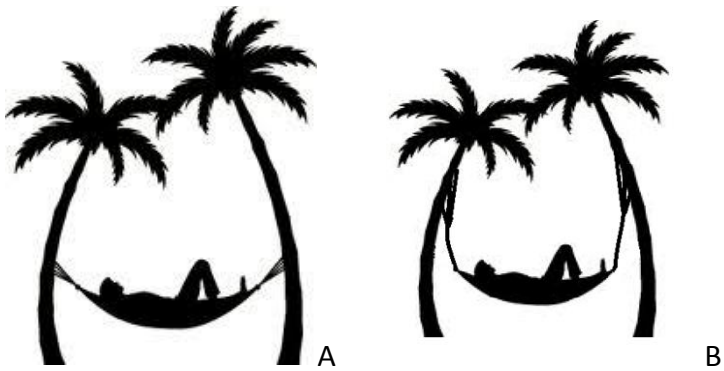

Fig. 2. In a) the hammock is tightly attached to the palm trees, while in b) it is loosely attached. Provided there is no external force, the main effect will be some amplification of the movement of the tourist's small movements. However if there is an external force, such as a moderate wind, then the tourist in a) will experience some limited movement, whereas the tourist in b) will experience more movement which may be amplified by the movement of the loose attachments.

So the data on the impact of parturition strongly suggest that, particularly in heifers, the initial claw-horn disease lesions develop in the immediate post-partum period and that management of heifers during this period is crucial (e.g. Webster (2001) showed that housing heifers in straw yards for 8 weeks after calving and then moving them to a cubicle yard prevented most

of the post-parturient rise in hoof horn haemorrhages seen in heifers housed in cubicle yards after calving.

Does body condition score loss lead to lameness or does lameness lead to body condition score loss?

It has long been known that lame cows lose bodyweight and body condition, but it is now clear that body condition score loss in non-lame cows is a significant risk factor for lameness. Both Randall et al (2015) and Lim et al (2015) showed that cows with a BCS <2.5 (5-point scale) had a significantly increased risk of becoming lame compared to cows with a BCS ≥2.5. Lim et al (2015) were also able to show that loss of BCS also increased of developing lameness, and in addition that change in BCS was also associated with the chances of recovery from lameness with BCS loss having a detrimental effect and BCS gain (in thin cows) having a beneficial one. There is thus a complex bidirectional relationship between BCS, BCS change and lameness.

These findings bring in to prominence the role of the digital cushion. The digital cushion consists of three parallel fat cylinders; axial, abaxial and central (Fig. 3). The axial and abaxial cushions are connected (in front of the flexor tuberosity of the distal phalanx) by multiple, transverse finger-shaped cushions. The flexor tuberosity itself is covered by the central fat pad. The main role of the digital cushion is to act as a dispersant across the pedal bone of the shock from placing the hoof onto the ground, but it also allows there to be significant movement of the pedal bone relative to the horn capsule.

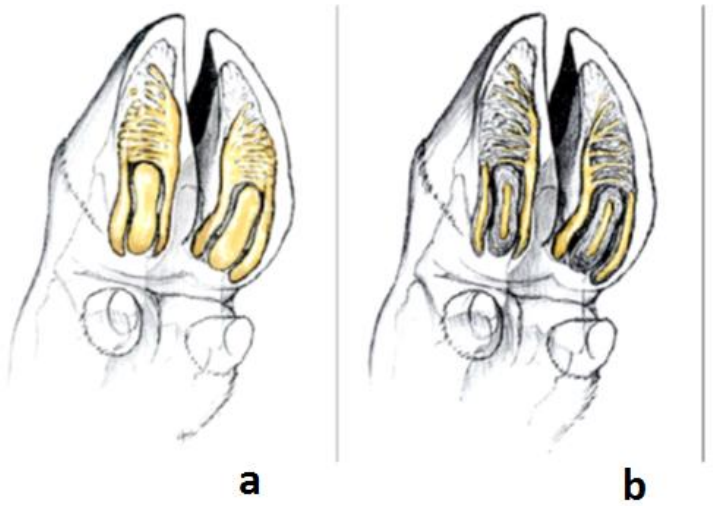

Fig. 3: Diagrammatic representation of the digital cushion. In a) the three parallel cushions can be clearly seen (normal situation); in b) the amount of fat in the digital cushions has been markedly reduced and it has been replaced by connective tissue (thin cow or previously lame cow). (From Lischer and Ossent 2002).

AS is illustrated in Fig.3, loss in body condition (either before or after lameness) results in a reduction in the amount of fat in the digital cushion

(Bicalho et al 2009) and a consequent reduction in its shock dispersant qualities. It thus seems that a well-developed digital cushion plays a major role in reducing the risk of lameness and in increasing the rate and chances of recovery in lame cows.

Lameness may have impact on the digital cushion in at least two ways; firstly, there is the simple link between lameness and reduced feed intake. If this leads to increased fat mobilisation, then it is likely that some of that fat will be fat in the digital cushion. In addition, the digital cushions may act as a local reservoir for arachidonic acid (the precursor to inflammatory prostaglandins), and this arachidonic acid may be released when there is tissue damage and compression which is sufficient to cause local inflammation. This may either reduce the amount of fat in the cushions or alter the cushions shock dispersing qualities.

It is thus clear that monitoring and management of BCS is crucial for both lame cows and non-lame ones if the prevalence of lameness is to be reduced. We need to minimise BCS loss in lame cows (which will speed recovery and, possibly, reduce recurrence) and need to optimise BCS (and minimise BCS loss) in non-lame cows (which will reduce the risk of lameness developing in those cows).

It also clear that the bidirectional association between BCS and lameness leads to a self-perpetuating negative cycle where an animal which is lame loses BCS and therefore is at increased risk of subsequent lameness.

Is lameness treatment successful?

We can clearly treat lame cows if the criteria for success are reduction in pain and apparent return to normal (or near-normal) locomotion. However as the studies on BCS show, lame cows, even when effectively treated by a veterinarian, still have a markedly increased risk of becoming lame again. So in terms of returning a cow to normality, lameness treatment is not successful.

It is likely that much of this is due to the delay in treatment, with cows having significant claw-horn disease for prolonged periods (>1 month) prior to being recognised as lame and treated. There is an increasing body evidence that early recognition and treatment of lameness (even if it is only moderate) can improve treatment success rates and reduce lameness prevalence (by reducing lameness recurrence) (Leach et al 2012; Thomas et al 2015).

It is likely that much of the benefit of early treatment is mediated by reducing the damage to the lame foot; however this may not be the only benefit. Thomas et al (2016) showed that treatment success (defined as a cow being non-lame 6 weeks after treatment) was markedly reduced when the delay in treating moderate lameness was only two weeks. They found that the main difference was that in the study where treatment was delayed a much higher proportion of cows were lame on the opposite limb 42 days after treatment than had been the case where treatment was instigated as soon as an elevated locomotion score had been observed. Interestingly, whereas adding a block

and an NSAID to trimming in the prompt study had increased treatment success rate, this was not the case in the delayed treatment study

This suggest that even in mild-moderate cases a short delay can have a significant impact in both the affected foot and in the opposite one. The delays built in to the study reported by Thomas et al (2016) were far shorter than is normally seen on farm, and the cattle were therefore still treated earlier than would have been the case if treatment had been farmer rather than research led.

We need more data on what is actually happening in the feet of cows during the early stage of claw-horn disease , but it is clear from recent research that we need to be focussing on treating cows earlier than is currently the case; i.e. when they are locomotion score 2 (on a 0-3 scale) rather than a score 3 cow.

What about the pedal bone.

Claw-horn disease is an inflammatory process once the damage has become severe enough. There has been very little investigation of the impact of that inflammatory process on the structures of the hoof, particularly in cows with repeated bouts of moderate lameness. However, recent research looking at the pedal bone of cull cows strongly suggests that lameness is linked to the development of bony exostoses on the pedal bone, particularly in the region of the flexor tuberosity.

Newsome et al (2016) showed that lameness history and age were both associated with these exostoses. Such exostoses are also common in cows which have undergone digit amputation, although there is a huge variation between cows with some claws having almost no exostoses and others having almost complete destruction of the joint surface (Laven unpublished observations). The study by Newsome et al (2016) was a post hoc analysis of bony change; as such it was never going to be a definitive study of the link between bony change and claw-horn disease. The main issue with the data is that effect of age on the development of exostoses is greater than the effect of lameness; however, it is quite feasible that the apparent age effect is mediated through multiple bouts of mild/moderate lameness which may have gone untreated. I New Zealand, lameness is significantly less common than in the UK (20 cases / 100 cows per year vs over 50 cases/ 100 cows per year), and preliminary studies suggest that bony exostoses are not common in cull cows (5 years +). Further research is needed.

If this hypothesis is correct then, bony change may be a key part of the self-perpetuating cycle of continuing lameness and could be a significant reason why lame cows go lame again. In addition, if as seems likely bony change is slow and therefore is more likely when lameness is prolonged and more severe than early treatment of lameness is likely to have long-term impacts as it reduces the risk of bony change. So the findings by Newsome et al (2016), if correct, add significantly to the push towards early diagnosis and treatment. If bony change is an important part of the pathogenesis of claw-horn disease then the findings of Newsome et al (2016) would have a major impact on our understanding of lameness prevention and treatment, which may be as

important as the impact of the research on parturition and lameness and the impact of the research on how poor body condition score produces lameness.

Conclusions

Our understanding of the development of lameness has increased significantly in recent years and it has become clear how much of a self-perpetuating process lameness is.

The key driver in dairy cattle is the direct effects of parturition which when combined with other lameness risk factors lead to the development of claw horn lesions. The key impact of parturition is to increase the likelihood of inappropriate forces on the corium and it acts together with other factors that can produce the same effect (such as poor environment and overgrown hooves) to turn minor damage into damage that is detectable at the claw surface (as haemorrhages). If the damage to the corium is severe enough then these haemorrhages develop into clinical claw-horn disease. BCS is important as it determines the ability of the digital cushion to absorb and disperse the shocks associated with standing and movement, particularly on hard surfaces. Low and reducing BCS thus increase the risk of factors such as poor environment producing corium damage.

The link to BCS is the first self-perpetuating negative cycle as lame cows lose BCS which makes them more prone to become lame and then more prone to lose BCS. The second self-perpetuating negative cycle is the development of bony exostoses as the result of chronic inflammation associated with lameness. These exostoses, even when small, significantly increase the risk of inappropriate forces on the epithelium of the corium, increasing the risk of more lameness and thus increased development of bony exostoses.

These negative cycles mean that we have to be much more proactive not only in preventing lameness but also treating it. Farmers across the world need to get the message that if they are only treating the lame cows that they see then they are treating cows too late. Cows should be treated as soon as they are detectably lame; this will only happen if farmers are actively looking (at least once a week for lame cows) and then threating those cows within 24 hours.

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Managing the transition from pasture to housing- the New Zealand experience

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The New Zealand dairy system is based on grazing grass throughout the year, with only limited use of supplements (principally palm kernel extract alongside hay and maize and grass silage). This can be achieved by seasonal calving in late winter/early spring alongside drying off in autumn when grass growth slows.

Dairying in New Zealand has therefore, traditionally, been a low input, low cost enterprise based on cheap feed – grazed grass. Maximising grazed grass is the key management role for farmers on New Zealand dairy farms – this is reflected in kgMS/Ha being the key economic benchmark for between farm comparisons. However, the situation is changing with an increasing number of farms becoming more reliant on supplementation, and more farms using off-paddock systems both covered and uncovered

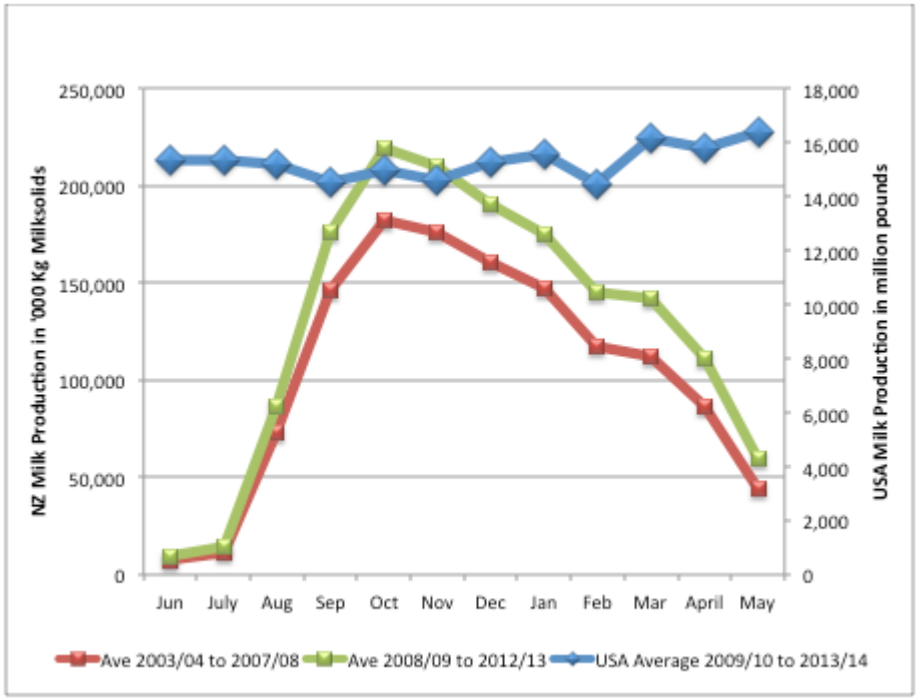

Fig 1: Seasonality of milk production (kg milk solids [MS]) in New Zealand (compared to US data). (From **http://tinyurl.com/NZ-milk-production)**

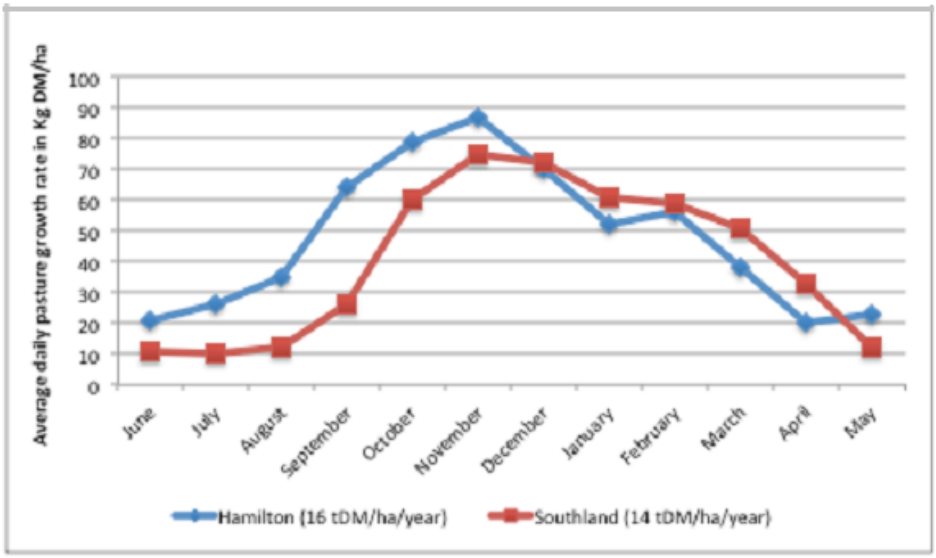

Fig 2: Grass growth rates on New Zealand dairy farms: Comparison of North Island (Hamilton) and South Island (Southland) farms. (From **http://tinyurl.com/NZ-milk-production**

The drivers of change:

1) Environmental degradation

Dairying in New Zealand has a detrimental effect on the environment, particularly when compared to other pasture livestock such as sheep. Water quality is a key issue with dairying producing significant amounts of excess nutrients, especially nitrogen (N) and phosphorus (P), that leach or run off into waterways. Environment New Zealand reported in 2007 (**http://tinyurl.com/environment-new-zealand-2007**) that 39% of monitored groundwater sites in New Zealand had nitrate concentrations greater than natural background levels, indeed in some water sources nitrate concentrations exceeded the drinking water standard of 11.3mg/L.

The increasing environmental impact of dairy farming in New Zealand has been driven by conversion of non-dairy farmland (particularly sheep) to dairy farms and by increased stocking density on dairy farms (from 2.10 cows/ha in 1982 to 2.87 cows/ha in 2013. So we have more cows on more land and less land per cow.

Keeping animals off pasture, particularly at critical periods in spring and autumn, can significantly reduce N and P leaching and run off (Christensen et al 2012); thus increasing environmental restrictions by regional councils have led to many farmers exploring the possibility of reducing grazing time, either by standing off cattle on uncovered areas or by building proper cow housing.

2) Welfare perception

Dairying in New Zealand has a 'clean, green' image. This is because of the perception that cows outside grazing is 'natural', that cows want to be outside

and that pasture is the most suitable place for a cow to be.

However, the expansion of dairying across New Zealand, especially the south of the South Island has meant that cattle are now kept in areas with cold winters where pasture growth is often insufficient to provide maintenance for dry cows (see Fig. 2). Alternative crops, particularly fodder beet, turnips, swedes and other brassicas, are now commonly used. Cattle graze on these leaving bare muddy paddocks. Particularly in wet conditions when farmers are trying to protect pasture from pugging, cattle are kept on these crop paddocks for prolonged periods of time. This further churns up the paddock increasing the muddiness of the paddock and dirtiness of the cows. Cow comfort is compromised as cows are reluctant to lie down, but there is very limited evidence of what the long term effect of this management strategy is.

Nevertheless, cows in mud up to their hocks is not a good 'look' and public perception is generally negative. Housing cows or using well-managed covered stand-off facilities avoids this problem, so some farmers particularly in Southland (the southernmost region of the South Island) have been building stand-off facilities in order to 'improve' animal welfare

3) Productivity

The New Zealand system, because it is based on grazed grass, is very dependent on land price. On most farms if you want to increase herd size (and thus farm income) you need to increase farm size. However, the move to dairy has meant that land prices have risen significantly more than the milk price; using inflation adjusted figure the current average price per hectare of dairy land (NZ$35 000) is 2.5 times what it was 20 years ago, whereas even in the boom year of 2013 the inflation adjusted milk price was only 50% higher than the average price in the late 1990s (and for the last two years it has been lower than that seen in that period) [Data from http://tinyurl.com/DairyStatistics-2013-14]

Although the New Zealand dairy cow produces only around 400 kgMS/year (equivalent to ~4500 L), it has the capacity to produce over 700 kgMS. Thus increasing the yield per cow is a potential alternative way of increasing income without purchasing expensive additional land. More effective use of pasture alongside better quality (higher ME) pastures can increase income cow, but supplementary feeding with non-pasture feed results in a much greater impact on yield.

In pasture-based systems, significant amounts of supplement cannot be fed at pasture, because the losses are too high. Thus increased supplements are usually fed on a feed pad or, increasingly, in a housing system.

These three factors, combined with a relatively high milk price in the first three years of this decade have resulted in a marked increase in the proportion of farms designated as 'high' input (i.e >20% of feed input purchased (see Fig 3); ; this has resulted in many farms developing additional facilities for feeding/standing off or housing cattle.

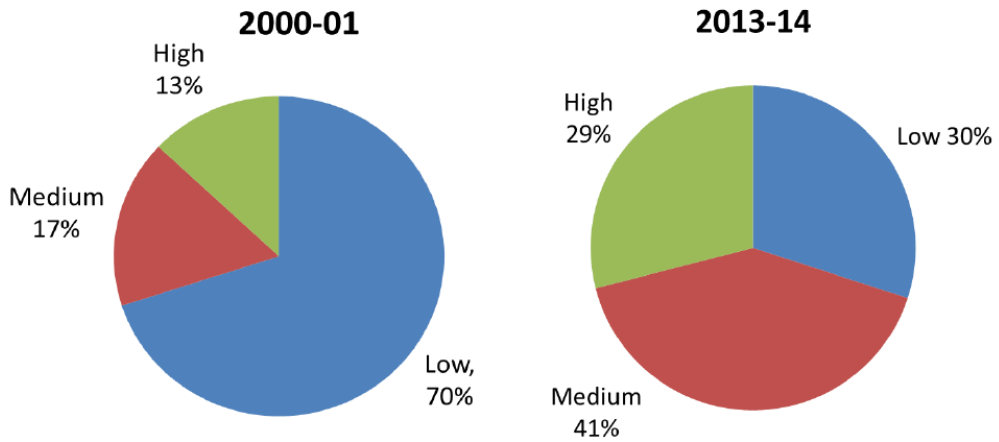

Figure 3: Change in system in New Zealand dairy farms. High: >20% of feed purchased; medium: 10-20% of feed imported, fed to milking and dry cows; low: feed may be imported (<15%) but fed only to dry cows.

How many are there?

A recent DairyNZ survey found that 24% of farms had an off-paddock facility (~2900 farms). Over 80% of these are uncovered facilities. The proportion of farms with an off-paddock system in each region is summarised in Fig. 4.

The most common such facility is the feed pad (accounting for 52% of all off-paddock facilities) – a feed pad is a defined hard surface area (usually concrete) where water and supplementary feed can be provided. It is not intended as a place for cows to lie. Stand-off pads (constructed of free-draining material, such as sand or woodchip, on a sealed surface) are the next most common facility (22%). In contrast to feed pads, these are designed to provide a lying space for cattle. The final uncovered facility is wintering (self-feed) pads; these are simply areas of material, such as woodchip which are laid directly on to pasture; these are used by about 7% of farms which have off-paddock facilities

In contrast, covered facilities are much less common. They can be divided into three categories: i) loose housing with bedding (such as woodchip) (6%); ii) loose housing with concrete floor (10%) and iii) cubicle (free stall) housing (2% - ~60 farms).

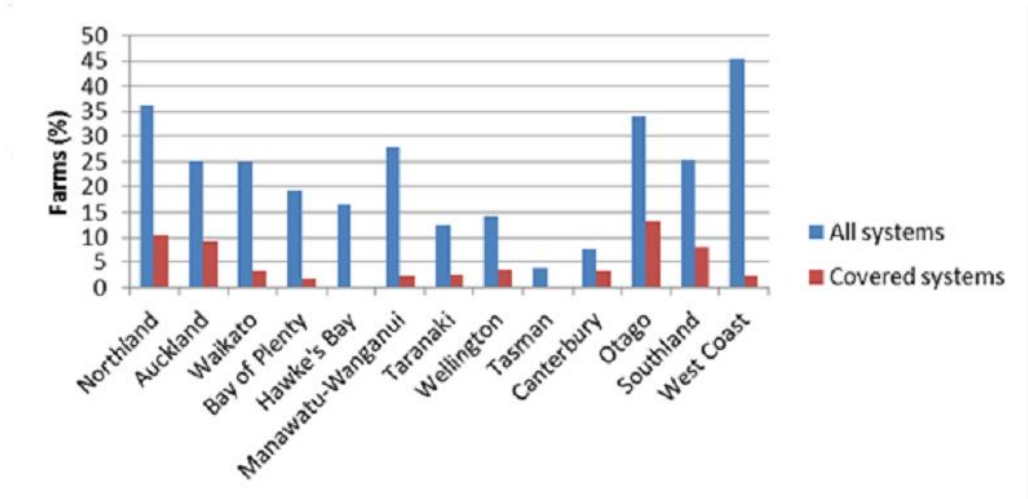

Figure 4: Comparison between regions in proportion of farms with off-paddock facilities. Note from left to right you go from north of North Island (sub-tropical) to south of South Island (cold temperate)

How are they being used?

The principal use of off-paddock systems is in protecting pasture during winter and spring. Thus, as for covered facilities, the majority of use of facilities occurs between May and September (Fig 5). Interestingly, despite being the most expensive covered system, the utilisation of cubicle yards (stalls) is significantly less than that of loose yards, particularly outside of the winter period.

3

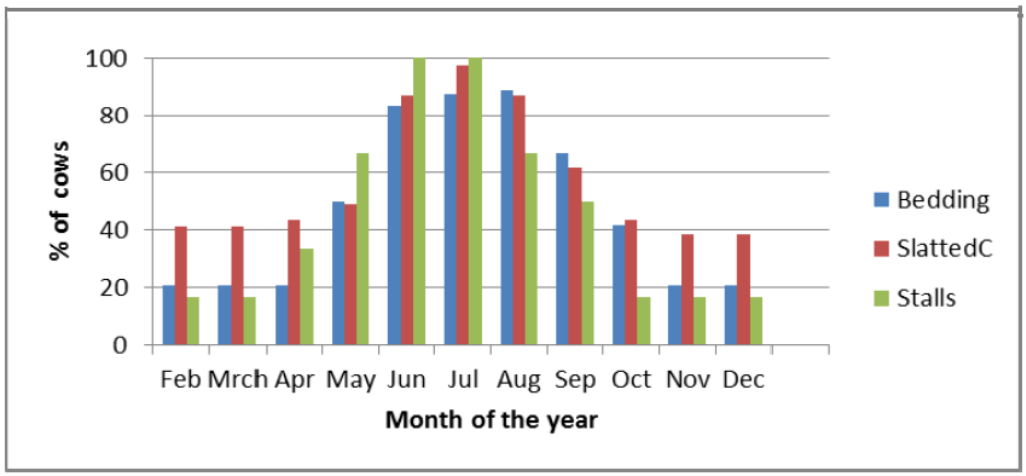

Fig. 5: Timing of the use of covered facilities (winter is Jun-Aug; spring is Sept to Nov).

The use of uncovered facilities is a lot more ad-hoc and weather dependent and therefore more variable, so a similar graph cannot be produced.

Nevertheless the proportion of time spent on such facilities mirrors the use of covered yards.

What are the key cow comfort issues?

In uncovered facilities the key issues are lying times and comfort while lying. These two factors are strongly linked. Before the development of off-paddock systems, pastures were managed by keeping cows on tracks (which link paddocks with the milking parlour) or by developing sacrifice paddocks, which work by restricting severe pasture damage to a small proportion of the grazing platform.

Neither of these is a suitable solution to the problem of pasture damage. Compared to lying times on a clean woodchip pad with good drainage, lying times on a track way and a small sacrifice paddock were significantly lower (11.9 h/day vs. 5.7 and 6.9 h/day respectively) (Fisher et al 2003) Keeping cows on concrete (i.e. keeping cows on a feedpad with concrete base) also reduces lying times (7.0 h/day; Fisher et al 2003). The difference was even greater on commercial farms. Stewart et al (2002) reported mean lying times of 11.3 h/day on woodchip compared to 2.9 and 4.1 h/day on concrete and trackways, respectively. These findings have resulted in the New Zealand code of welfare recommending: "After standing on concrete surfaces for 12 hours or more per day, for more than three consecutive days, cows should be given at least one full day on a suitable alternative surface, where they are free to lie down and rest." However, the same document states that "the welfare of cows for which lying is restricted to four hours each day, for up to four continuous days, is compromised"; a target which was not exceeded even in animals kept on concrete in the study reported by Fisher et al (2003).

So the situation in New Zealand is currently vague, with most of the emphasis placed on avoiding keeping cows for more than 3 days on concrete even though lying times in sacrifice paddocks can be just as short.

The use of these alternatives reflects the focus of the New Zealand dairy farm on pasture management rather than cow comfort, even though the evidence that pasture productivity is better when these alternatives are used is very limited. This is particularly so for 'sacrifice paddocks' which as well as sacrificing the paddock, 'sacrifice the cows and future productivity' (Ian Lean, personal communication).

So alternatives are needed to keeping cows on wet winter paddocks. However as Fisher et al (2003) shows, these alternatives need proper planning and simply using existing tracks or feed pads does not result in a satisfactory solution. The lying times reported by Fisher et al (2003) for woodchip stand-off pads are acceptable; however these are only achieved in situations where cows kept on the stand-off pads for short periods of time. Prolonged use, particularly in wet conditions (which is when they are going to be used) leads to markedly reduced lying times (to as low as 2h/day; Longhurst et al 2013) as the woodchip surface becomes converted to mud. Lying times can be maintained by regular application of woodchips onto the pad, but this is expensive and most farmers are reluctant to do this.

The data thus suggest that uncovered off-paddock systems are either unacceptable except for very short periods of time (<12 hours) (feed pads or trackways) or acceptable for periods of up to but no more than 3-4 days (woodchip yards). This is reflected in the results of a survey of New Zealand dairy farmers using such facilities; all the farmers with a concrete surface that reported health problems had cases of lameness, compared with 71% of farmers using concrete in combination with another system and 25% using woodchip pads (Stewart et al 2002). However, mastitis was much more commonly reported by farmers using woodchip pads – probably because cows actually lay down in these yards!

If topping-up of pads is not going to be used then the only feasible alternatives to pasture are covered yards as the covering protects the bedding from the elements. However, loose housing currently accounts for <1/2 of the housing on farms. By far the most common covered system is the loose house where the floor is slatted concrete. One of the company's manufacturing and selling the housing have claimed that a 'greenhouse effect' dries the faeces and provides a more comfortable bedding than would otherwise be the case. However, the author's personal experience is that, unsurprisingly, the thin layer of dry faeces does not provide a comfortable lying surface. Some farmers, particularly when housing late dry cows do use additional bedding (usually straw) but the amounts used are often very small by international standards, principally because of the cost of the straw.

There are limited published data on lying times in loose house with concrete flooring; but on commercial farms mean lying times are ~8 h/day, but there is significant individual variation and a high proportion of cows (63%) had lying times below the 8 hour figure (Dalley et al 2012). Further research is ongoing but it is likely that such houses are best used as a high quality feedpad rather than a 'cow house', with the same restrictions applying to them as for non-covered concrete feed pads.

Covered bedded loose housing would seem to be an attractive alternative to non-covered pads and covered slatted concrete floors. However, they do require significant management, especially when stocking density is <9m^2/cow , which is very common on New Zealand farms as the recommendations are that 5m^2/cow is sufficient if cattle are only housed for short (undefined) periods of time (Stewart et al 2002). However even when stocking rates are 8.6 m^2/cow prolonged use of covered woodchip yards without effective replenishment of the bedding leads to significantly reduced lying times (Davison et al 2015). So the same issue apply to covered woodchip yards as to uncovered ones, in that there is resistance to taking the time required to effectively manage the yards and to ensuring that the quality of the bed is maintained by continuously replenishing the woodchip. Further research is required to evaluate the optimal method of management of covered woodchip on New Zealand dairy farms, bearing in mind that they are going to be used for shorter periods of time than covered housing on Northern Hemisphere farms.

This leaves cubicle (free stall) housing. Currently there are very few farms with this type of housing. The main drawback is the cost which is ~$5000/ cow space. These high costs, combined with limited understanding of cow house construction by the local building industry means that there is constant pressure to reduce costs by altering the design of a house. This often results in poor quality housing, particularly in terms of cow comfort. Changes include 3-row rather than 2-row cubicles, reducing water troughs and feeding space, and eliminating passageways between cubicles, so that cows in the middle of the house have to walk to the end to get access to the feed passage. There is also a focus on reducing costs and time when managing the building. This means that sand bedding, even though it provides significant cow comfort is unpopular, and perhaps more importantly bedding on top of mast/mattresses is not commonly used. These changes mean that many of the cubicle houses would be substandard if in Europe or North America. However, the limited use of these buildings may mean that their impact is less than it would have been if cows were permanently housed during winter. For example, hock injuries (a simple measure of cubicle comfort) have been much higher this year in the housed cows at Massey university (35% affected, mean longest diameter <1.5 cm; author, unpublished observations). The cubicles are no more uncomfortable this year than in previous years; the crucial difference is that in the winter/spring of 2015 cows spent >80 days indoors whereas in previous years this was <40. The hybrid pasture-housed system allows cows to recover from housing problems, therefore reducing the impact of poor housing on cow health and welfare. However, this may not always be the case if poor housing is combined with poor management at pasture (such as long distance walked, pressure on cows on poor tracks, poorly designed collecting yards), then it is quite possible that the two systems could interact to make cow health, especially lameness, much worse.

Conclusions

Changes in dairying in New Zealand have meant that managing cows exclusively at pasture all-year-round is no longer the standard system on many farms. In particular, managing cows at pasture in winter and early spring has become a problem, especially on farms with high sticking rates or on farms in the south of New Zealand. This has meant that more farms are using off-paddock facilities; however there are no simple options. Uncovered facilities are not suitable for anything other than short term use, while covered facilities are more expensive and, if not managed effectively, may have similar impacts on welfare to uncovered ones. The key to good management is changing the focus of the New Zealand dairy farmer to manging the cow rather than the pasture. However this is likely to be difficult because even in intensive systems efficiently grazing grass is likely to stay a major driver of profitability. Thus increased use of housing requires staff to be able to manage pasture and cows; this will require significant focus and training.

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Lameness Monitoring, Use of Locomotion Scoring

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Summary:

Lameness, due to its detrimental effect on cow welfare, health and production, in dairy cows has received quite a lot of attention in the last few decades, not only in terms of prevention and treatment but also in terms of detection, as early treatment might decrease the number of severely lame cows in the herds as well as decrease the direct and indirect costs associated with lameness cases. Assessment of lameness prevalence and severity requires visual evaluation of the locomotion of a cow. Scoring cows for lameness based on changes in locomotion or behavior is essential for farmers to find and treat their lame animals. Human observation of locomotion, by looking at different traits in one go, is used in practice to assess locomotion. Welfare schemes including locomotion assessments are increasingly being adopted, and more farmers and their veterinarians might implement a locomotion-scoring routine together. Generally, lame cows are detected by the herdsman, hoof trimmer or veterinarian based on abnormal locomotion, abnormal behavior or the presence of hoof lesions during routine trimming. In the scientific literature, several guidelines are proposed to detect lame cows based on visual interpretation of the locomotion of individual cows (i.e., locomotion scoring systems, LSS). Monitoring herd lameness prevalence has utility for dairy producers and veterinarians in their efforts to reduce lameness, for animal welfare assessment programs, and for researchers. Locomotion scoring is a method used to quantify lameness and calculate prevalence.

Introduction:

Dairy farming has improved in past 30 years in Iran. By the time high producer farms (Over 40 lit/day, average of 12000 lit/ 305 days) have improved. As a result, dairy farming systems have intensified, with more cattle on fewer farms and per caretaker and higher productivity per animal as is the case in other parts of the world. This trend reduces the farmer's available time to observe and monitor the cows and jeopardizes the health of the cows, in particular the high-yielding ones. Lameness is considered to be the third most costly health problem of dairy cows, after reduced fertility and mastitis. In Iran in some situations infectious diseases are more prevalent than lameness. Nevertheless, lameness has not only been under-recorded on farms but its importance with regard to cow welfare, cow health and farm profitability has also been hugely underestimated. Although in some dairy farms an intensive hoof care program have been started, still many dairy farmers are unaware of the number of lame cows in their herd, and, if noticed, they often do not have enough time to treat them. Generally, lame cows are detected by the herdsman, hoof trimmer or veterinarian based on changes in cow gait, posture

or behavior or the presence of hoof lesions during routine trimming.

Lameness detection:

Lameness can be defined as the clinical manifestation of painful disorders, mainly related to the locomotor system, resulting in impaired movement or deviation from normal gait or posture. It should be noted that abnormal gait may develop not only as a result of disorders in the locomotor system but also disorders in other organs. Although changes in the general behavior of cows, like lying, standing or feeding behavior, have been associated with lameness, changes in locomotion are the most commonly used and most direct ways to monitor lameness.

As a short history of locomotion scoring systems (LSS) as a visual tool and accompanying lameness indicators Manson and Leaver were the first to describe locomotion scoring in cattle in detail. Cows were scored using a 9-point scale based on the absence or presence of tenderness, abduction and difficulty in turning/rising/walking. Wells et al. proposed another system mainly focusing on gait asymmetry and restriction of movement. In this system, only 5 different locomotion classes were used. Sprecher et al. introduced a 5-point lameness scoring system that assessed gait with special emphasis on back posture, both while standing and walking. In addition, short striding and weight bearing between different limbs were used during scoring. Winckler and Willen modified the Sprecher method and introduced their 5-point scoring systems using the following criteria: irregular gait, short striding and reluctance to bear weight. Breuer et al. introduced head bobs in a 4-point scoring system. Flower and Weary proposed head bobs, tracking up and joint flexion as gait indicators to look for lameness. Arc of the foot flight, foot placement relative to body position, limb axis and foot rotation during weight bearing of every limb were looked at by Dyer et al. in their aim to identify lame and sound limbs. The Welfare quality assessment protocol for lameness in cattle focuses on irregular footfall, uneven temporal rhythm between hoof beats and weight not borne for equal time on each of the four feet.

How, When and Where can we do LSS?

Because of the time necessary to locomotion score each cow in large dairy herds, a sampling strategy to determine herd lameness prevalence that allows scoring of fewer cows would be useful. Such a sampling strategy must be validated for accuracy compared with the lameness prevalence when all cows in a herd are locomotion scored. Three previously suggested methods of estimating lameness prevalence by strategic sampling of dairy herds were assessed. Sampling strategies tested included (1) sampling a calculated number of cows in the middle third of the milking parlor exit order for each pen, (2) sampling a calculated number of cows weighted across pens and distributed evenly within each pen, and (3) sampling all cows in the high production, low production, and hospital pens. Sampling strategies using the middle of milking parlor exit order and a calculated sample distributed across the herd may be used to obtain an estimate of herd lameness prevalence.

Environmental or cow factors can contribute to locomotion changes not related to lameness and hence, might cause false alerts. Effects of wet surfaces, dark environment, age, production level, lactation and gestation stage on cow locomotion were investigated. In dark environments and on wet walking surfaces cows took shorter, more asymmetrical strides with less step overlap. In general, older cows had a more asymmetrical gait and they walked slower with more abduction. Lactation stage or gestation stage also showed significant association with asymmetrical and shorter gait and less step overlap. When comparing the sensitivity for the detection of non-lame cows, sensitivity increased by 10% when the age and lactation was added in the algorithm (sensitivity was 70% and 80% for the first and second algorithm, respectively). Results of the study shows that using knowledge on influencing factors on cow locomotion will help in reducing the number of false alerts for lameness detection systems under development. However, further research is necessary in order to better understand these and many other possible influencing factors (e.g. trimming, conformation) of non-lame and hence 'normal' locomotion in cows.

Tied cows were considered lame when two of the following indicators were visually present: repeated weight-shifting between feet, rotation of feet from the line parallel to the midline of the body, standing on the edge of a step, resting a foot, and uneven weight bearing when moving from side to side. In contrast to the visual locomotion scoring systems described above, some systems are based on scoring different gait characteristics separately from 1 (normal) to 5 (severely abnormal), such as tracking, spine curvature, speed, head bobbing, general symmetry and abduction/adduction. Most of the visual locomotion scoring systems described in the literature use a specific number of classes ranging from non-lame to severely lame, often referred to as a numerical rating system (NRS). The number of classes range from 2 (lame/none lame) to 9 and allocation to a class depends on the absence or presence of gait characteristics, which differ in degrees of severity between each of these classes. Another approach uses an overall visual analogue scale (VAS). This is generally a continuous 100-unit line with at both ends of the scale the most extreme conditions of the characteristic. If VAS is used for general lameness scoring, those extremes would be ‘perfect gait’ and ‘cow unable to move’. Flower and Weary suggested that such a scoring system might be more sensitive than NRS as it allows observers to record more subtle changes in gait characteristics.

Individual locomotion traits that were most related to locomotion scores in dairy cows, and consistent capabilities of experienced raters in scoring these traits were studied. Locomotion and 5 individual locomotion traits (arched back, asymmetric gait, head bobbing, reluctance to bear weight, and tracking up) were scored independently on a 5-level scale for 58 videos of different cows by 10 experienced raters in 2 different scoring sessions. All traits were significantly related to the locomotion score when scored with a 5-level scale and when classified as

(severely) lame or non-lame. Odds ratios for altered and severely altered traits were 10.8 and 14.5 for reluctance to bear weight, 6.5 and 7.2 for asymmetric gait, and 4.8 and 3.2 for arched back, respectively. In conclusion, raters had difficulties in scoring locomotion traits consistently, especially slight alterations were difficult to detect by experienced raters. Yet, the locomotion traits reluctance to bear weight, asymmetric gait, and arched back had the strongest relation with the locomotion score. These traits should have priority in locomotion-scoring-system guidelines and are the best to be used for the development of automated LSS.

If clinical signs predictive of lameness could be observed more conveniently, as cows are undergoing regularly scheduled examinations while standing, detection levels could increase. The association between postures observed while cows are standing in stanchions and clinical lameness evaluated by locomotion scoring, and the observation of these postures as a test for lameness were evaluated. In a study, cows were observed while standing in stanchions for regularly scheduled management procedures and the presence of arched back and cow-hocked, wide-stance, and favored-limb postures were recorded. The same cows were locomotion-scored as they exited the milking parlor. Back-arched, cow-hocked, and favored limb postures were associated with lameness but were not highly sensitive or specific as diagnostic tests. However, observation of back arch may be useful to identify cows needing further examination.

Analysis of scores, however, is done after transformation of the original 5-level scale into a 4, 3, or 2 level scale to improve reliability and agreement. Different ways of merging levels to optimize resolution, reliability, and agreement of locomotion scores were evaluated. Overall intra- and interrater reliability and agreement and specific intra- and interrater agreement were determined for the 5-level scale and after transformation into 4, 3, and 2 level scales by merging different combinations of adjacent levels. The specific intra rater agreement was 76.4% for locomotion level 1, 68.5% for level 2, 65% for level 3, 77.2% for level 4, and 80% for level 5. Specific interrater agreement was 64.7% for locomotion level 1, 57.5% for level 2, 50.8% for level 3, 60% for level 4, and 45.2% for level 5. Specific intra- and interrater agreement suggested that levels 2 and 3 were more difficult to score consistently compared with other levels in the 5-level scale. The acceptance threshold for overall intra- and interrater reliability and agreement and specific intra- and interrater agreement was exceeded only for the 2-level scale when the 5 levels were merged as (12)(345) or (123)(45). In conclusion, when locomotion scoring is performed by experienced raters without further training together, the lowest specific intra- and interrater agreement was obtained in levels 2 and 3 of the 5-level scale. Acceptance thresholds for overall intra- and interrater reliability and agreement and specific intra- and interrater agreement were exceeded only in the 2-level scale.

Agreement, reliability, and validity of manual and automatic locomotion scoring systems (MLSSs and ALSSs, respectively) used in dairy cattle lameness research were compared and

evaluated. There are many different types of MLSSs and ALSSs. Twenty-five MLSSs were found in 244 articles. MLSSs use different types of scale (ordinal or continuous) and different gait and posture traits need to be observed. The most used MLSS (used in 28% of the references) is based on asymmetric gait, reluctance to bear weight, and arched back, and is scored on a five-level scale. Fifteen ALSSs were found that could be categorized according to three approaches: (a) the kinetic approach measures forces involved in locomotion, (b) the kinematic approach measures time and distance of variables associated to limb movement and some specific posture variables, and (c) the indirect approach uses behavioral variables or production variables as indicators for impaired locomotion. The utilization of MLSSs and ALSSs should aim to the prevention and efficient management of conditions that induce impaired locomotion. Long-term studies comparing MLSSs and ALSSs while applying various strategies to detect and control unfavorable conditions leading to impaired locomotion are required to determine the usefulness of MLSSs and ALSSs for securing optimal production and animal welfare in practice.

Consistency of LSS, change between observers, cows, field conditions…….

Locomotion scoring requires the observer to distinguish normal from abnormal walking behavior. Since scoring is based on observer judgment it is open to some degree of interpretation. Hence, observers should be trained and retrained by observers familiar with the scoring system in order to obtain a high degree of agreement between and within observers. As with every new observation, observers gradually build up more experience with the scoring system and with the range in which indicators can be shown, they will also drift in interpretation of the borders of each specific class. Periodical re-training is therefore advised to reach an acceptable level of inter-observer reliability. Using fewer locomotion classes is sometimes suggested to improve intra- and inter-observer reliability. The intra- and inter-observer variation of locomotion scoring systems for cattle have been assessed in several studies. Engel et al. pointed out that when using discrete scores, cows that were in between categories might be scored in different classes by less trained and trained observers even if they had more or less the same opinion. In the study of O'Callaghan et al. the intra- and inter-observer reliability using a 5-point scale were 56 % and 37%. These scores increased to 93% and 81%, respectively, when a one-point difference was allowed.

High within-observer agreement is a prerequisite for obtaining valid mobility scorings, and within-observer agreement cannot be estimated in a barn, because the gait of cows is dynamic and may change between 2 occasions. The within-observer agreement according to the observers' educational background and experience with cattle, based on video recordings with very diverse types of gait were studied. Groups of farmers, bovine veterinarians, first- and fourth-year veterinary students, researchers, and cattle-inexperienced sensory assessors evaluated mobility using a 5-point mobility score system developed

specifically for walking cows (n=102 observers). The evaluation sessions were similar for all groups, lasted 75 min, and were organized as follows: introduction, test A, short training session, break, and test B. In total, video recordings of 22 cows were displayed twice in a random order (11 cows in each test × 2 replicates). When adjusting for the fixed effects of video sample and gait scoring preferences, the probability of assigning the same mobility score twice to the same cow varied from 55% (sensory assessors) to 72% (fourth-year veterinary students). In general observers could categorize the mobility characteristics of cows quite well. Observers who preferred to assess the attributes back arch or the overall mobility score (based on uneven gait) had the highest agreement, respectively, 69 or 68%. The mobility score achieves sufficiently high within-observer repeatability to allow between-observer agreement estimates, which are reliable compared with other more-complex scoring systems. Consequently, the new scoring scale seems feasible for on-farm applications as a tool to monitor mobility within and between cows, for communication between farmers and veterinarians with diverse educational background, and for lameness benchmarking of herds.

The gait attributes commonly used in subjective locomotion scoring systems and use new technology to evaluate these gait attributes objectively on 60 Holstein lactating dairy cattle were explored. Kinematic gait analysis more commonly used in sports and equine science was adapted for use on dairy cattle to assess stride characteristics, joint flexion, and spine posture in dairy cows with different lameness status. Cows that were lame had shorter stride length and had negative tracking distance compared with non-lame cattle. Lame cattle did not show any difference in spine posture when walking. Gait alterations were more evident in cows with sole ulcers, which showed considerable shortening of stride and had more negative tracking compared with cows with no hoof lesions. Cows with sole ulcers also showed significant shortening of the spine when walking than cows with no hoof lesions.

Locomotion scoring changes during time, procedures and lesion occurrence:

The association between locomotion scores and lesions were investigated and it was concluded that the presence of a lesion does not imply that it is necessarily associated with increasing locomotion score. The lack of association between certain lesions and poor locomotion scores indicates either that these lesions are causing different severities of lameness, or that the case definitions used were not sufficiently precise. Locomotion score may not be sensitive enough to detect all lesions (and possibly discomfort).

The same idea happen in our field, It was shown that sole ulcer and interdigital necrobacilosis increase locomotion score but digital dermatitis does not necessarily increase locomotion score. In other findings just 52% of the scored cows show a lesion in their feet that varies between different scoring times and persons who scored (28-72%). Rezaei et al. reported a potency of high LSS in detecting lesions in zone 4 of the claws (sole ulcers)

In practice it was claimed that cows with high locomotion scores stay in high scores for a long time as Keyvanirad et al. showed that two month after a high LSS (4 and 5) in a five point locomotion scoring, 57.01 cows still remain in the same scores, three month later it reduce to 36.84, four month later it reduced to 21.92% and five month after scoring still 7.01% of the cows were in high locomotion scores. Shafigh et al. reported a variation between 43.55-56.99 % stability of high LSS in a month after the first treatment. However Khalilifard et al. reported an elevation of the LSS two month before till two month after occurrence of the lesions. Hashemifard et al. reported an elevation of LSS three month before to three month after claw horn lesions.

Although some researchers believe that parity, days in milk and body condition score may affect locomotion scores, Mohamadnia et al. reported an insignificant elevation in scores 1 and 2 in a five point scale LSS after hoof trimming and the overall increase was not significant. Khaghani et al. didn't record any changes in LSS after parturition.

Estimates of point prevalence suggest that locomotion scoring identifies three times as many lame cows than when estimated by farmers. The impact of under-recognition on the interval between identification of lameness (using locomotion score) and treatment were evaluated. Survival analyses were used to quantify the number of days between identification of a specific locomotion score and presentation, by farm staff, of a cow for lameness treatment. All cows which had a locomotion score of >3 were presented for lameness treatment subsequently, although >40% were treated more than 3 weeks after being identified. Only 75% of events where cows had a locomotion score of 3 were followed by treatment with >65% of those treatments occurring >3 weeks after the first score of 3. Improving the recognition of lameness by farm staff is thus likely to appreciably reduce the interval between reduced mobility and lameness treatment. However Khaghani et al., 2012 reported an almost equal occurrence of the lesions in cows that were referred to hoof trimming chutes by dairy labor and the cows with high LSS.

Locomotion scoring, lying behavior and lesion recording during hoof trimming are all ways of evaluating hoof health in dairy cows. The relationship between these measures in a random sample of 1340 cows from 42 Danish dairy herds were evaluated. The hypothesis was that locomotion scoring and/or the monitoring of lying behavior could be used as tools to identify cows with hoof lesions, either of the horn or of the skin. Cows were locomotion scored, lying behavior recorded and data on hoof lesions seen during hoof trimming collected. The results were analyzed using logistic regression with hoof lesion as the outcome and locomotion score (1-5), mean duration of lying bouts, parity and lactation stage as explanatory variables. This analysis was undertaken for all types of lesions, for hoof horn lesions only and for skin lesions only. It was concluded that locomotion scoring and duration of lying bouts may be used as tools in the management of hoof health in dairy herds.

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Bio – Surveillance and Biosecurity: A Promising action to stop the incidence of Digital Dermatitis in dairy Cows

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Bovine Digital Dermatitis (BDD) has been found a reputation of being cosmopolitan, emerging with apparent infectious nature. It negatively affects animal welfare and production. Body of evidences indicates that BDD is a multifactorial, Involving environmental management and microbial factors and currently is the Problematic infectious skin disease frequently in dairy cattle with lameness various solution have come in and out of fashion without any Justification and still had a lot of question marks regarding origin / source. Skin of digital region mostly at the planter and dorsal aspects of the interdigital space is a target zone for lesion development. It was stated that any breach in the normal skin structure from direct abrasion or chemical contact with the skin, will allow micro - organisms to invade the underlying tissues and provoke an associated inflammatory response where the local body deference mechanisms have limited access to such a lesion, the infection may not be contained and either the integrity of that tissue or the health of the whole body can be compromised. Today it was cleared that BDD is patently a disease with very significant bacterial involvement , group of Treponema and plenty opportunistic Invaders of tissues was blamed for such infection .Treponema medium, T. vencentti – link , T. denticola / T. Putidum – link all are three polyogroups of Treponema consistently identified together in typical BDD foot lesion . it is still unclear whether the Treponema's are merely secondary invaders or have a primary role in lesion development . Since the first reported outbreak of BDD from PO valley, Millan. Italy on 1974, the clinical picture of BDD lesions and the panorama of disease changed significantly due to aggressive medicament and not correct way of treatment. The 5 lesion stages by using the so – called "M-Stage" classification system making accurate assessment of BDD lesion transmissions for control treatment Policy to be taken at Prompt action .M., early, small circumscribed red to gray epithelial defects less than 2cm in diameter that may spontaneously resolve or precede into acute stages of DD(M2) .In addition , M1 stage can appear between acute episodes of lesion or within the margins of a chronic M4 lesion as an intermediate stage . M2 acute , active ulcerative (bright red) or granulomatous (Red – gray)digital skin alteration ,> 2cm in diameter , commonly found along the coronary band in addition to around the dew claws , in wall cracks and occasionally as a sole defect . M3 , healing stage within 1to 2 days after topical therapy , where the acute DD lesion has covered itself with a firm

scab – like material . M4, late chronic lesions that may be dyskeratotic (Mostly thickened epithelium), proliferative or both . Lesions may be filamentous, scab – like or mass proliferations. M4.1 consisting of a chronic M4 Lesion with an early or intermediate M1 lesion within its perimeter. Reducing the number of individual cases of M2 lesion through early detection and treatment is crucial disease management. In this regard healing lesion with a small ulcerated lesion on the top of the healing lesion (M4-1) may perpetuate infection within a herd. Based on the principles of moist wound healing, the wound dressing serves as a reaction chamber for immune cells and provides a transport for body's own regeneration process. Therefore, supporting the natural healing process, stimulating natural function, painful lesions caused by BDD are rational. It was claimed that topical application containing copper and zinc sulfate have achieved cure rates comparable to antibiotic treatment. Should keep in mind cure is defined the transition of M2 lesion into a healing (M0) or a non-painful chronic stage (M4) at day 28 after initiation the treatment. It seems the epidemiological pattern of BDD has been missed interpreted and there is a need to be asked of why, when and how it comes to a herd, stay there and not wish to go out. The transmission between cattle is unclear, the foot to foot contact, direct skin to skin contact have not clarified yet and the questions of what are the reservoirs of Treponema infection in cows or on farm environment, how are the Treponema's transmitted between cows in herd still remained to be answered and in one word where the "NICHE " must be , may be as biofilm. Recent evidences put stress on the invasion of Treponema's to the necrotic tissues, and non-healing hoof lesion such as toe necrosis. These should be considered as reservoirs of infection. Chronic lesions (M4) could be acted as the long term reservoirs of pathogens and the precursors of active lesion. Increased chronic lesion become a problem under the impact of risk factors such as bad hygiene. Several alternative niches for BDD treponemes have been claimed. It may survive in environment slurry and on the skin surface at least for short periods of time. This might suggest that direct skin contact or short term persistence in slurry could be the rout for DD Treponema transmission, but controversy exist. On potential means of controlling infection is this disruption of transmission, however, the infection reservoirs and transmission routes of BDD have yet to be elucidate. To this end organized bio- surveillance and treatment plan also showed that individual cow factor play an important role in the development of the visible lesions of Digital Dermatitis and that this may be independent of serological response recently advised. The two components of biosecurity measures namely, bio-exclusion, relates to preventive measures (risk reduction strategies) designed to avoid the introduction of pathogenic infections (Hazards) and bio- containment relates to measures to limit within – farm transmission of infectious hazards and onward spread to other farms. The implementation of these plans showed how they act properly to minimize the risk of acquiring more sever forms BDD in endemically infected herds. Without asking for anything in return, as recently stated, using the Mastitis

Analogy , Digital Dermatitis can be considered as " Mastitis of Foot" then dry period infections are of importance and hence dry cows, pre-calving heifers, young heifers and premature calves needed to be monitored and acted on. Last not least, intensive intervention programs based on active long-term DD surveillance ,mitigation of risk factors and prompt treatment are expected to increase overall animal well being and farm profitability by minimizing the effect of DD especially during the first lactation. On the final words as distinguished professor Nigel B. Cook stated in his interesting article recently published in the AABP Proceedings book ,Vol.48,2015, page 88, given the UBIQUITY of the condition .it is likely that BDD deserves the title of being the most infectious disease present on modern dairy operation.

Acknowledgement:

My sincere gratitude goes to Arad Hoof-Care Group , Seyed Mohammad Karbalaei Seyed Javad, Fahimeh Zibaee, Fatemeh Katoli, Narges Eftekhari, Golnar Vakilgilani, and Hossein Shad for their kind collaborations and their generous support. Thanks also to Dr. Ali Mohammad Golshani Head Behban Shimi R&A group for his valuable comments I received.

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Cow handling and its importance in preventing lameness

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Abstract:

The dairy industry has seen an increase in the number of cows per farm around the world. This translates into more frequent human-animal interactions on farms. Sadly, farm animals have sometimes been subjected to aversive handling which can lead to being fearful of people, increased handling problems (such as injuries to both animal and humans) and reduced animal welfare. Poor handling techniques have also been shown to affect the productivity of commercial farm animals. However, it has been shown that the environment and facilities where the interactions occur can also affect the outcome of the interaction. Hence, Facilities and handling techniques can both affect lameness in a herd. Available space per cow in the holding yard, use of backing gate, rotary platform exit and the concrete surface of the holding yard are some examples.

Some handling techniques can exert unnecessary pressure on cows' feet making them prone to developing lameness causing lesions. Considering the amount of interactions between cows and farm staff on farms, there is little we know about this topic in the dairy industry. The importance of staff training in low-stress cattle handling is often underestimated by farmers and farm health advisors. By improving our knowledge of safe and effective animal handling techniques and improving our facilities we have the potential to decrease lameness and increase animal productivity.

Key words: Cattle handling, Lameness, Welfare

Digital Dermatitis: New Ideas on an Old Disease

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Abstract

Approximately 42 years ago Drs. Cheli and Mortellaro published an article describing the disease of digital dermatitis (DD). To this day, despite millions of dollars spent on research of this disease, it remains a major cause of lameness in dairy and beef cattle throughout the world. Our research team at Iowa State University has centered much of its attention on the developmental aspects of DD, with specific emphasis on the etiology and epidemiology of the disease, in hopes of finding better methods of treatment, control and prevention. Early studies were designed to monitor the progression of DD lesions from the earliest to the mature lesion stages. Despite our attempts to use the popular "M" system of lesion scoring, it failed to properly differentiate the various morphologic variants of early stage lesions observed in our studies. Therefore, we developed and validated (using a variety of techniques) a lesion staging system that classified early lesions as: Type A (1 and 2) lesions described as small focal ulcerated lesions and Type B lesions (1 and 2) which are diffuse encrusted acantholytic lesions. "Classic lesions" were categorized as Stage 3 (an easily visible ulcerated lesion) or Stage 4 (thickened chronic lesion with or without filiform outgrowths of epithelium). Using metagenomics to assess the microbial populations in each stage of the lesions we have demonstrated an abundance of Treponema spp. in mature (Stage 3 and 4) lesions. However, we found that early stage lesions have only minor populations of Treponemes and are characterized by a much more diverse population of organisms. This suggests that non-Treponemal species may be responsible for initiating lesion development, with Treponemes representing secondary invasion later in the disease process. Based upon careful monitoring of DD lesions in cows over a 3 year period, it was observed that the progression of lesions from an early to mature lesion state occurred over a mean of 147 days (range 37 to 522 days). This is corroborated by our clinical observation of DD in feedlot cattle in North America, whereby most cattle enter the feedlot free of DD; but develop mature lesions by 3 to 4 months after their arrival. Treatment of DD is normally accomplished on farms in the US by a one-time topical application of tetracycline under a loose wrap. Despite the popularity of the treatment approach our research suggests that single time-point treatment with tetracycline has a high level of recrudescence. Of 44 classic lesions topically treated with tetracycline, all but 6 lesions recrudesced. In addition to our studies of the disease and its treatment in cattle, we have also tried to determine possible reservoirs of the disease in the dairy farm environment. In total, 204 different samples were collected from a single DD positive dairy farm, and an additional nine samples were collected from alley flush water or manure lagoons of other farms known to have DD. Treponema positive samples were typically found in higher numbers and in a larger prevalence from animal associated samples and hoof trimming

equipment, although samples derived from animal bedding, equipment and the farm worker environments were also positive.

Digital Dermatitis in Dairy and Beef Cattle

Digital dermatitis (DD) is considered to be the most common infectious disease affecting housed dairy cattle world-wide. It is estimated to affect nearly 100% of dairy herds and up to 20% of all dairy cattle. A study published in 2000 of cull dairy and beef cattle in the southeastern United States also found a higher prevalence of digital dermatitis in dairy compared with beef cattle. Researchers examined the left hind foot for lesions of digital dermatitis in a total of 815 cattle during 4 visits to a slaughterhouse. Twenty-two of 76 (29%) dairy cattle and 29 of 739 (4%) beef cattle were observed to have lesions of digital dermatitis. Male beef cattle were more likely to have lesions compared with beef females. Results of this study confirm that although prevalence is lower, DD does occur in cow/calf operations as well.

Although Italian researchers Cheli and Mortellaro are credited with being the first to describe digital dermatitis, there's evidence that a veterinarian from the US could have justified similar fame. In 1974, a veterinary practitioner from Vicksburg, Mississippi, reported observing papillomas (warts) occurring on the feet of a mature Angus bull. Lesions were described as beginning on the pastern and coronet of the rear feet and gradually spread upward to the dewclaws and fetlock. Attempts to isolate viruses from the lesions were unsuccessful and despite multiple attempts at therapy the disease was refractory to treatment. Of interest, none of the treatment approaches involved topical antibiotics. It's unknown whether the condition described here was actually DD, however considering its similarities to digital dermatitis, one might wonder if topical antimicrobial treatment might have proved beneficial based on the poor response to therapy.

In feedlot cattle DD occurs sporadically in some locations of the country and in near epidemic proportions in others. Although there are no published data on incidence, clinical observation suggests incidence rates as high as 50% or more in pens of affected cattle. One of the troubling features of DD is that lameness is often

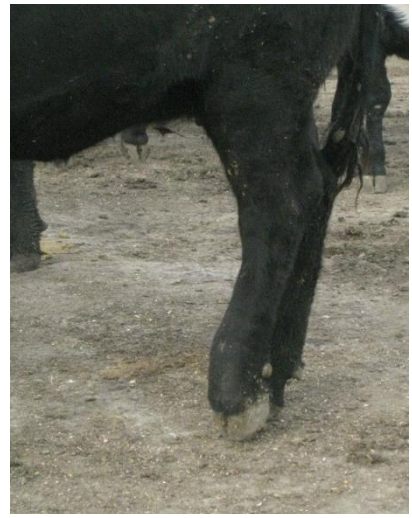

Figure 1.Typical posture of a steer with digital dermatitis affecting the plantar interdigital cleft.

inconsistent. Less than half of affected cattle may demonstrate obvious signs of lameness. Observations from a large study at Iowa State University

over a 3 year period of time strongly suggest that nearly all early lesions and a significant percentage of advanced lesions fail to result in visually detectable lameness (i.e. a locomotion score greater than 3 on a 5-point scale). In our study only a portion of the cows with clinical lesions had lameness. Similar results were observed by Frankena and co-workers where only 39% of the cows with severe DD lesions had lameness. These observations suggest that lameness is not a good means of identifying the prevalence of cows with DD lesions. It simply misses too many.

Detection is often based on direct observation of lesions or a finding of variable degrees of lameness amongst cattle within a pen. Cattle with lesions on rear feet often exhibit a characteristic posture whereby they will shift weight to the less severely affected foot and place weight on the painful foot onto the toe thereby placing less stress on the skin on the plantar surface (See Figure 1).

Characteristic Appearance of DD Lesions

Lesions of DD are typically observed in one of 3 locations of the foot: 1) on the skin of the plantar aspect of the rear foot adjacent to the interdigital cleft, 2) on the interdigital skin and 3) at the skin-horn junction of the heel bulbs. Less frequently, lesions may be observed near or above the dewclaws. From our research work at Iowa State University, we have found that it helps to categorize lesions into two major groups, pre-clinical and clinical. Pre-clinical lesions are the early stages of lesion development that are easier to treat and generally do not cause clinical lameness. Clinical lesions are those that have a deeper seated infection making them more difficult to treat and are capable of causing clinical lameness.

For research purposes we subdivide these stages into additional classifications to better understand lesion development and treatment responses; however that level of complexity is not generally necessary for making clinical decisions. For example, in our staging system "pre-clinical" stages of developing lesions (A Type) are usually observed on the plantar interdigital cleft and subdivided into A and B type lesions. A-type lesions are a spreading non-proliferative lesion, whereas B-type lesions are more of a focal or multifocal crust with acanthosis. Classic (i.e. mature)

lesions are generally red, circular or oval with a raw ulcerated surface that frequently border the interdigital cleft (Figure 2); however they may be found anywhere on the foot from the dewclaws on down to the coronet (skin-horn junction) . As lesions

Figure 2.A lesion of digital dermatitis in an atypical location on the lateral side rear foot.

mature they develop a granular appearing surface similar to that of a wart. The borders of mature lesions are often clearly demarcated by the presence of hypertrophied hairs.

Chronic lesions are characterized by a thick bed of granulation tissue and in some cases epithelial outgrowths that appear as long hairs extending from the surface of the granulation tissue bed, thus the common name – hairy heel wart. Digital dermatitis lesions are extremely sensitive and very painful when touched or disturbed.

Lesions also have a characteristic odor believed to be caused by the breakdown of keratin and the presence of secondary bacterial infection. Finally, mature and particularly chronic lesions are accompanied by significant erosion of the heel horn. The heel erosion may be diffuse, in the form of fissures, or in the shape of a "V". In some cases the erosion may result in significant undermining of heel horn.

Pain is a key feature of DD lesions, so animals will naturally learn to adjust posture and walk in a manner that avoids discomfort. Hoof trimmers know to carefully examine a foot with an abnormally long heel or toe; because the shape of a hoof is an important indicator of foot problems. In the case of chronic DD lesions, animals will adjust their posture and gait to avoid contact with flooring surfaces. For example, when lesions occur on the plantar surface of the foot animals will shift their weight to the toe as shown in Figure 1. This causes greater wear at the toe and less at the heel permitting the heel to become abnormally long. Lesions occurring on the front of the foot will cause the animal to shift its weight to the heel resulting in a longer toe and shorter heel. Therefore, claw conformation can be a very useful diagnostic indicator of DD lesions in cattle.

Causes of DD

For the past 25 years researchers have consistently isolated bacterial spirochetes from DD lesions. The majority of these spirochetes have been

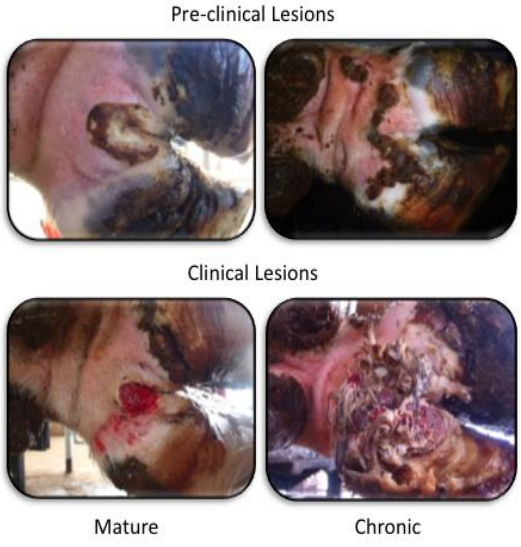

Figure 3: Typical appearance of different stages of Digital Dermatitis lesion development. The top pictures demonstrate the two pre-clinical lesion types. The bottom pictures show clinical lesions with the mature lesion on the left and a more chronic lesion on the right. (Note lesions are shown on dairy cattle with white feet to make the lesions easier to visualize)

identified as belonging to the genus Treponema sp. causing many to conclude that Treponemes are the most likely causative agent of DD. However, the bacterial flora of the foot includes a multitude of other bacteria, some capable of causing disease and some not. Nonetheless, questions remain as to whether DD is solely caused by Treponemal spirochetes, by other associated bacteria or is it a combination of both?

Studies by Krull et al, at Iowa State University suggest that more than Treponemes are likely involved. Evidence for this comes from several observations: 1) attempts to reproduce the disease by skin inoculation with pure cultures of these microorganisms have largely failed to cause disease, 2) vaccines prepared against spirochetes have not proven to be effective for control of DD, 3) a large number of different bacterial organisms can be identified in the lesions including multiple types of Treponemes, and 4) the lesions of DD respond favorably to antibiotics. At present the data suggest that the disease process is poly-microbial (i.e. poly-bacterial), meaning that multiple species of bacteria need to be present at the same time in order to induce disease. A very similar disease process associated with similar Treponeme species is human gingivitis where there is a large body of evidence that multiple bacterial species are required to induce disease. Not surprisingly, poly-bacterial diseases are much more complex to study and understand which likely explains the difficulty researchers have experienced in determining the cause of this disease.

Treatment of DD

Treatment of Individual Animals with an antibiotic compound such as oxytetracycline or tetracycline soluble powder with or without a bandage is the most common form of individual treatment on dairy farms. It is labor intensive and effectiveness depends upon the nature of the lesion with respect to chronicity (i.e. early, mature or chronic).

Our research group has been evaluating the clinical response to treatment with topical antibiotics. Several key factors have been confirmed. First, we have confirmed the results of other researchers that demonstrate that the majority of lesions that are treated a single time with topical tetracycline fail to completely heal. Treatment does often improve lameness and the lesions tend to improve and some will return to a pre-clinical stage; however over time most lesions persist or recrudesce (reoccur). Second, our data suggest that there is not a significant difference in lesion recrudescence between the mature and more chronic lesions. So, treatment of all observed clinical DD lesions is warranted. Finally, we have demonstrated that when lesions heal completely (i.e. return to normal skin) they are much less likely to recrudesce. This finding would suggest that more aggressive follow-up to topical treatment with retreatment until the skin completely heals may be warranted.

Topical antibiotic sprays

Have been shown to be very effective for treatment of DD. Although labor intensive, it offers a couple of

advantages over footbath treatment approaches. For one, this treatment method is not affected by freezing temperatures and secondly, DD lesions can be sprayed with full-strength solutions that haven't been subject to contamination and possible neutralization by organic matter. While this approach to treatment and control may seem too cumbersome, some argue that in feedlot situations spraying is easier than trying to construct and manage a footbath.

Walk-Through Footbaths

The use of a walk-through footbath is the most popular approach to treatment of DD in dairy cattle; but there is little information in the scientific literature to support its efficacy. Products or compounds suggested for use usually include copper sulfate, zinc sulfate, formalin, and various antibiotics. In feedlot conditions one of the first challenges is finding the best location for a footbath so that it can be properly used and maintained. The next issue is design of the footbath; if the footbath is too short animals will jump over it and if it is too narrow animals will step around it. Based on the dairy industry's experience longer (12 ft.) footbaths are likely to increase the number of foot immersions per trip through the bath.

Prospects for Vaccination to Control DD

History suggests that developing a vaccine may be difficult. Results from early studies of a Treponema bacterin for control of DD in cattle concluded that immunization could reduce clinical disease. However, commercial use proved otherwise and the vaccine was eventually removed from the market. The US experience with vaccination for DD was corroborated by German researchers who found no benefit from a vaccine containing herd-specific pathogens including Treponema sp. While interest in finding a vaccine continues to be the focus of many who research this disease, there are many questions to be answered in the process of finding permanent solutions through vaccination.

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Treatment of Claw Lesions: Necessary or Not

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Abstract

Topical treatment of claw lesions is common practice in the United States. According to a recent US survey regarding treatment of claw lesions, topical treatments were applied by 59% of veterinarians and 53% of hoof trimmers. The medication used most frequently was the soluble powder form of tetracycline (Tet) or oxytetracycline (Oxytet); used by 48% of veterinarians and 81% of hoof trimmers. The second most common product varied by user group with copper sulfate (CS) for veterinarians and ichthammol ointment (a sulfurous, tarry compound with mild antiseptic properties used primarily as a drawing agent) for trimmers. These compounds, particularly Tet and CS, have properties which are considered to be potentially deleterious to the healing of lesions. Tetracyclines are known to cause significant tissue irritation when used parenterally, CS is corrosive to the skin and eyes and both compounds may be absorbed through cutaneous tissues and open lesions. Considering what is known about the pathogenesis of claw lesions and the process of wound healing, there is reason to believe that topical treatment may not be beneficial. Sole ulcers occur secondary to mechanical loading properties associated with claw horn overgrowth and metabolic conditions that weaken the suspensory apparatus of the third phalanx. Healing of claw lesions occurs by second intention; that is, lesions are not sutured but left open to heal by the process of granulation tissue formation, re-epithelization and contraction of the wound edges. Wound healing of open lesions by second intention generally requires additional time compared with lesions closed surgically (i.e. by first intention) because of the time needed to generate a sufficient volume of connective tissue to fill the defect. Since the epidermis provides an important barrier to infection, the risk of infection is higher while the wound is open, and this serves as the argument for the use of topical treatment of claw lesions. However, topical treatments with a low pH (e.g. Tet) or corrosive properties (e.g. CS) are believed to cause cellular toxicity which might interfere with epithelial cellular migration and proliferation in the early stages of wound healing. The result is granulation tissue formation and inhibited epithelization and wound contraction. A small study was conducted to assess the effect of topical treatment with Tet and CS on the rate of wound healing as determined by the presence of granulation tissue and evidence of re-epithelization at day 21 post treatment. Photos of lesions at day 21 were presented to 2 independent observers who scored the lesions for the visual presence of granulation tissue and evidence of re-epithelization. Based upon observer scores at day 21, lesions topically treated with oxytetracycline (Oxytet) or CS were more likely to have granulation tissue ($p > 0.0054$) and less likely to have evidence of re-epithelization ($p > 0.0553$). Although the number of observations was small, the data suggest that topical treatment with Oxytet or CS may delay wound healing.

Introduction

Our research group at Iowa State University was awarded a grant from the Hoof Trimmer's Association and American Association of Bovine Practitioners Research Foundation at the annual conference in September 2012. The title of the project was: "Topical Treatment of Claw Lesions in Dairy Cattle". The objectives of the study were three-fold: 1) to determine current claw lesion treatment practices used by trimmers and veterinarians, 2) to assess the effect of claw lesion treatment practices on the healing rate of claw lesions, and 3) to determine the potential for treatment to result in detectable residues in milk. The following is a summary of the study and our findings.

A 3-Part Study

Part 1 of our study was designed to document claw lesion treatment practices used by hoof trimmers and veterinarians with specific reference to method of corrective trimming used, topical treatments applied, use of wraps or bandages and foot blocks. Members from both the HTA and AABP were asked to complete an on-line survey of their foot care practices. Preliminary results of the survey were presented as an abstract and poster at the 46th Annual Conference of the Bovine Practitioners in Milwaukee, Wisconsin. An abstract of the results were also presented at the International Symposium and 9th International Conference on Lameness in Ruminants, in Bristol, United Kingdom, August 11-14, 2013. The full version of the survey was published as a peer-reviewed article in The Bovine Practitioner in 2014 (Kleinhenz et al, 2014).

Part 2 of our study was intended to determine if current treatment practices are beneficial or potentially detrimental to claw lesion healing rates. For cows to be enrolled in the trial, they were required to meet the following criteria: 1) lame cows with a sole ulcer or white line lesion which had caused exposure of the underlying corium (either by the consequence of the disease or corrective trimming) and 2) only cows with new lesions (no chronic lesions or cows with a history of claw disease). Reasoning for these criteria was based upon our trial objective which was to assess the length of time required for re-epithelialization of lesions.

A third component of the study was to assess the potential for topical treatment of claw lesions with either tetracycline or oxytetracycline to result in detectable residue. Survey results confirmed our hypothesis and affirmed the necessity to determine if detectable residues were possible following topical treatment with these drugs. While there are a couple of reports in the literature (Britt, JS, et al, 1999: Cramer, G, et al., 2014) on the detection of residue following topical treatment of digital dermatitis; there are none to date that describe residue detection in cows with claw lesions topically treated with these compounds.

Animals, Lesion Selection and Treatment Groups

Animals and Lesion Selection: Eighteen lactating Holstein and Jersey

cows from the Iowa State University (ISU) dairy diagnosed with uncomplicated sole ulcers or white line lesions were randomly enrolled into either a treatment (10) or control (8) group. Researchers attempted to enroll only those cows with new lesions since our thinking was that to enroll animals with chronic lesions might confound the results. Healing of long-standing lesions is often complicated by permanent damage to the corium which prevents normal healing.

Treatment Groups: Animals assigned to the treatment group received corrective trimming, the fitting of a claw block to the contralateral healthy claw and topical treatment as follows: cows assigned to the topical treatment groups received a topical application of 7.3 g of oxytetracycline HCl soluble powder (7) or topical copper sulfate (3) using a powdered formulation of copper sulfate. Oxytetracycline was chosen for study as our survey indicated that tetracycline or its derivatives were one of the most commonly used topical treatments on claw lesions. Copper sulfate was included since survey respondents reported that it was also commonly used, particularly in organic operations. All lesions were wrapped with a co-flex bandage following the application of topical treatments. Wraps were removed after 24 hours to assess lesions. No further treatment was applied.

Animals in the control group received corrective trimming, a wrap and a foot block applied to the contralateral healthy claw; but no topical treatment. Wraps were removed after 24 hours (at day 1) for lesion assessment procedures. No further topical treatment or bandage was applied beyond the day 1 assessment.

Lesion Evaluation Procedures

Lesion Photos: Photo images of claw lesions were taken at the time of enrollment (i.e. day 0), day 1 and at the third evaluation occurring 21 days post treatment. On day 0, the day of treatment, the foot was trimmed and treated according to group assignment. A loose wrap was applied to all animals including those in the control group. On day 1 (24 hours after enrollment) the loose wrap was removed from all animals followed by gentle cleansing of the lesions with water to avoid disturbing raw corium tissues. Lesions were subsequently photographed and the cow was released with no further treatment or bandaging of the lesion. All cows were reexamined at day 21 to assess wound healing progress and photograph lesions. Photos were maintained in a database for future evaluation by 2 observers who were blinded to treatment group.

Assessment of drug residue in topically treated animals: Corrective trimming of claw lesions generally results in the exposure of raw corium tissues. To date, there have been no reports of the potential for antibiotic residue following topical treatment of claw lesions. In order to determine the likelihood of creating a detectable residue in blood or milk we collected blood and milk samples from 11 cows with topically treated claw lesions. Seven cows (Farm 1) were treated with oxytetracycline soluble powder (7.3 grams) and 4 (Farm 2) with 1 scoop (equivalent to 25.5 grams) of tetracycline soluble powder. Blood

and milk samples were collected pre and post-treatment as follows: oxytetracycline treated cows sampled 3X/day and the tetracycline treated cows were sampled 2X/day for 3 days post treatment. Serum and milk samples were frozen after collection and submitted to the Pharmacology Analytical Support Team (PhAST) at Iowa State University's College of Veterinary Medicine. Drug concentrations were quantified using liquid chromatography-mass spectrometry with a level of detection for the assays at 1 ng/ml. Lesion surface area (exposed corium) was also calculated using ImageJ software (available from National Institutes of Health).

Results

At the start of study we found several animals with lesions that met the requirements for enrollment; however over time fewer animals were presented with lesions fitting the study criteria. Investigators attribute part of this lack of suitable candidates for study to seasonal effects of lameness (higher incidence rates occur in the late summer and early fall) and high beef prices, which resulted in higher culling rates and thus fewer animals available for study. As a result only 18 animals were available for study.

Visual Assessment of Lesions: Photos of lesions from day 1 and day 21 were presented to 2 observers who were blinded as to treatment group. Each was asked to evaluate the lesions for the presence or evidence of inflammation, granulation tissue and re-epithelialization. As might be expected, there was no statistically significant difference in lesions at day 1 for any of the parameters assessed.

Figure 1.Cow 7894 - Lesion on day 1 following treatment with 7.3 grams of oxytetracycline woluble powder.

Figure 2.Cow 7894 - Lesion with exhuberant granulation tissue on day 21.

For the day 21 photo observation, evaluators were asked to determine if lesions had evidence of excessive granulation tissue formation or evidence of re-epithelialization. Based upon observer evaluation of the photos of lesions at day 21, lesions topically treated with oxytetracycline or copper sulfate were more likely to have granulation tissue ($p > 0.0054$) and less likely to have evidence of re-epithelization ($p > 0.0553$). Although the number of observations is small, these data suggest that topical treatment with oxytetracycline or copper sulfate may delay wound healing.

We speculate that this increase in excessive granulation tissue formation negatively impacts healing rate and may increase susceptibility of these tissues to secondary infectious diseases such as digital dermatitis. Similar to proud flesh in equines, trimming or removal of exuberant granulation is necessary to promote healing. A smooth bed of healthy granulating tissue on lesion surfaces is desirable, but when the granulation process becomes excessive or exuberant, healing is likely to be delayed. This is supported by a previous report from van Amstel et al., who found that lesions observed to have a marked granulation tissue response were also slower to heal (i.e. form new epithelium). Topical steroids were observed to dampen the inflammatory response but also reduce neutrophil migration and the production of inflammatory mediators.

Assay for tetracycline/ oxytetracycline residue in topically treated animals:

Results of assays for tetracycline in plasma demonstrated a C_{max} (maximum or peak concentration) of 4.78 + 2.82 ng/ml; for milk C_{max} was 20.64 + 14.51 ng/ml (recorded at the 3rd milking on day 2). C_{max} for oxytetracycline in plasma was 2.15 + 1.20 ng/ml (recorded at 48 hrs. post topical application); for milk C_{max} was 20.81 + 19.90 ng/ml (recorded at the 7th milking (milking 3X/day). Regulatory action for oxytetracycline and tetracycline are > 300 ppb, which is well above levels observed in this study; but all post treatment samples had detectable levels of drug.

It was also observed that lesions with larger surface areas tended to have higher log-transformed drug concentrations in both plasma ($R2 = 0.51$; $P = 0.03$) and milk ($R2 = 0.44$; $P = 0.03$). One might conclude that while topical treatment with either tetracycline or oxytetracycline derivatives is likely to result in detectable residues, concentrations are well below actionable levels.

Discussion

Wound healing is a very complicated process usually described in terms of three (some do not include hemostasis) or four overlapping phases including hemostasis, inflammation, proliferation, and maturation. The primary objective is a rapid unimpeded re-epithelialization of the lesion. Research on the healing of claw lesions shows that depending upon severity and other complications, this process may require as little as 25 days or in complicated situations as much as 42-60 days. Lischer et al. (2001) evaluated healing rates on 74 cows with 105 claw lesions over a 6-month period. Their data indicated that the mean time for the formation of a closed layer of new epithelium was 25 days for lesions causing slight corium alterations, 33 days for moderate corium alterations, and 42 days for lesions causing severe alterations of the corium.

In this study claw lesions treated topically with oxytetracycline or copper sulfate were more likely to have excessive granulation tissue and less new epithelium at day 21 post treatment compared with non-treated controls. Topical medications used in the early stages of wound healing cause necrosis (i.e. death of tissues) that interferes with cellular migration and epithelial cell proliferation, key events in the wound healing process. Research on wound healing in equines has shown that topical treatment with

acidic compounds or agents with corrosive properties are capable of causing cellular toxicity. In fact, the equine literature lists a vast array of compounds (that are also commonly used in cattle) that are capable of adversely affecting wound healing including strong iodine, copper sulfate, tetracycline and its derivatives and other products (Auer and Stick, 2012). This information and the results of this study strongly suggest that if topical treatment is necessary, it needs to be accomplished with compounds that will not cause additional tissue damage or interference with wound healing.

This study is the first to report on the potential for drug residue from topical treatment of claw lesions. Although the levels of drug detected in both plasma and milk were well below regulatory limits for tetracycline, it is nonetheless important to know that absorption of the drug does occur following topical treatment of lesions. One might speculate that in small herd situations where many animals may receive topical treatment, sufficient absorption of the drug could occur to result in a violative residue.

Clinical observation of animals with claw lesions topically treated with tetracycline derivatives or copper sulfate (CS) suggest that these compounds cause significant irritation and pain in the immediate post-treatment period. To assess the possible effects of topical therapy with Oxytetracycline soluble powder (Oxytet) and CS on discomfort in the immediate post treatment period, a simple ethogram was developed to record behavioral indicators of pain. Primary behaviors monitored included: lifting of the foot or leg and toe touching (i.e. resistance to placing the foot firmly on the ground). Over a period of 15 minutes in the immediate post treatment period we observed that cows treated with either Oxytet or CS exhibited nearly 3 times as many pain-related behaviors (mean of 4.5/15 min for cows with no topical treatment compared with a mean of 13.6/15 min. for cows treated with Tet or CS). We conclude that these compounds increase post treatment discomfort. Assuming topical treatments as used in this study appear to delay healing, could result in an antibiotic residue and seem to increase post treatment discomfort, we conclude there is little benefit to topical therapy of claw lesions.

In Summary,

Investigators would readily concede that this study has not yielded the definitive answer to the question of whether topical treatment procedures are beneficial or detrimental to the healing rates of claw lesions. Instead, our results on a limited number of animals suggest that topical therapy with tetracycline derivatives (and possibly copper sulfate) increases inflammation causing pain in the immediate post treatment period, a greater tendency for the formation of granulation tissue and reduced epithelialization of lesions (i.e. delayed healing). These data suggest that the objective of treatment should be to remove all necrotic tissue and undermined claw horn without causing damage to peripheral healthy tissues. This in combination with the application of a foot block to the healthy claw is sufficient in most cases to reduce discomfort and promote recovery of claw lesions. Consistent with previously published information, there does not appear to be any

advantage to topical treatment with either tetracycline or copper sulfate and a bandage or loose wrap. Finally, our study of cows with topically treated claw lesions using tetracycline derivatives confirms that such treatment results in detectable residues in plasma and milk. Levels detected are well below actionable levels, but nonetheless significant.

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Benchmarking lameness and skin injuries: Engaging producers and improving practice

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The Problem

Lameness is now recognized as of the most prevalent and costly maladies affecting the dairy industry today (Bruijnis et al., 2013; Chapinal et al., 2013). Although we are slowly becoming aware of how prevalent lameness (cows showing noticeable weight transfer off the affected limb) is on dairy farms in many parts of the world (Austria, Canada, China, Finland, Germany, Italy, Netherlands, New Zealand, Norway, UK and the US (e.g. Amory et al., 2006; Barker et al., 2010; Chapinal et al., 2014a; Dippel et al., 2009; Fabian et al., 2014; Kielland et al., 2009; Popescu et al., 2014; Sarjokari et al., 2013; von Keyserlingk et al., 2012) little is known about the prevalence of lameness in other parts of the world (e.g. South America, Eastern Europe or the Middle East). Collectively the available work to date indicates higher prevalence's in zero grazing (intensive) systems, averaging about 25%, with a trend toward lower prevalence in grazing systems (e.g. 8% in New Zealand; Fabian et al., 2014).

Regardless of the lameness prevalence in a particular region it appears that dairy producers tend to underestimate the amount of lameness in their herds (United Kingdom, Whay et al., 2002; USA, Espejo et al., 2006; New Zealand, Fabian et al., 2014). Recent reports in the US show that despite lameness being accepted as the primary welfare concern facing farmers, current methods of intervention to reduce the risk for lameness are lagging (e.g. von Keyserlingk et al. 2012). The problem therefore appears two fold: firstly, farmers routinely underestimate lameness on their farms and secondly, tremendous variation exists between and within regions and countries as well as between production systems (see von Keyserlingk et al., 2012). We suggest that tailored solutions will likely work best if we are to try and reduce lameness prevalence. The first objective of this conference proceeding chapter is to firstly describe how benchmarking lameness and skin injuries has proven useful in reducing lameness prevalence. Our second objective is to show how working with farmers in this manner provides rich datasets that allow for risk factor analyses that help identify solutions to lameness (and injuries) on dairy farms.

Individual farms - tailored solutions and the role of benchmarking

The issue of cow comfort, and how it relates to the risk of lameness and injuries, has received considerable interest. Factors related to how the facilities are designed and managed may influence cow's behaviour. The University of British Columbia developed and piloted a program focused on assessing lameness on farms in British Columbia (Ito et al., 2010) and this has now expanded onto

farms in Eastern and Western USA (see von Keyserlingk et al., 2012) and China (Chapinal et al., 2014). The results have been used to benchmark farms relative to peers in the same region. Benchmarking compares farms 'like-with-like' and helps to identify areas of underperformance relative to the best performers in the industry. To date, these studies have focused primarily on the high production lactating cows in intensively housed systems located in western Canada and some US states (e.g. California, Vermont, New York, and Pennsylvania).

One of the most interesting findings of our work was that some farms were able to achieve extremely low levels of lameness whereas others were challenged in this area – have lameness rates well in excess of global average of 25% cited above (see von Keyserlingk et al., 2012), In Figure 1 we show our findings from our work summarizing our visits to 121 farms visited in British Columbia (BC), California (CA) and the North Eastern United States. You will see that the prevalence of clinical lameness averaged 28%, 31% and 55% respectively in these regions. The rates of severe lameness were considerably lower but equally worrisome as these are far more likely to be associated with pain (see companion proceedings chapter by Weary and von Keyserlingk); the prevalence of severe lameness averaged 7% in BC, 4% in CA, and 8% in NE.

Benchmarking – providing dairy farmers with their own evidence

What has become clear to us is that by providing farmers 'benchmarking'information we are able to facilitate conversations between the various stakeholders involved in caring for cows on a particular farm. At each visit we provided each farmer with a confidential report that they could used as a vehicle for discussion (ideally together with the farm workers involved in caring for the cows, the herd veterinarian, hoof trimmer and nutritionist and any other consultants involved in the day to day care of the animals) to develop evidence based changes in management practices to address the challenges presented in the report. By providing farmers with the report, together with averages from other farms in their region, they are able to identify areas of success on their farm and areas where work was still needed.

As an example we have provided the prevalence data we collected in British Columbia and the US (see Figure 1). As you can see there is variation within a region, some farms doing an outstanding job where as others are struggling with high rates of lameness. Once provided the information farmers are then able to make evidence based decisions and also to reflect on their industry as a whole. For instance, the farm in California that had the lowest prevalence of lameness (~5%) immediately asked what he needed to do in order to reduce this to zero. He also quietly stated that the fact that some farms had a prevalence in excess of 60% were a challenge for the dairy industry as a whole. In contrast, when visiting one of the farms that had ~60% lameness prevalence the farmer was extremely concerned and was motivated to try and find a solution.

Unlike alterations in locomotion which farmers struggle to identify without training (Endres et al., 2006), hock lesions are easily identified in the milking parlour. Injuries on cattle are

normally associated when the animals come into physical contact with aspects of the housing environment, with abrasions on the knees and hocks the most common. These injuries can be as small as hair loss the size of a coin to swelling and open wounds that range from small to large (see companion proceedings paper on cow comfort assessment).

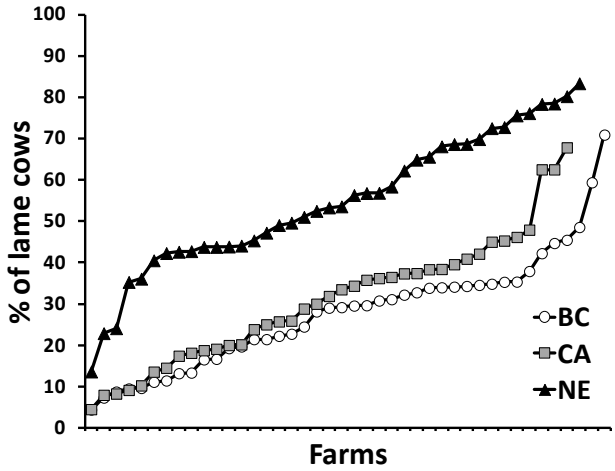


Figure 1.Clinical lameness in British Columbia (BC), California (CA) and the North Eastern US (NE); farms are ranked lowest to highest (from von Keyserlingk et al., 2012)

In our study (described in von Keyserlingk et al., 2012) cows on each farm were scored for hock condition (lateral surface of the tarsal joint) on a 3-point scoring system developed initially by Cornell University; where 1 =healthy hock, 2=bald area on the hock without evident swelling, and 3=evidently swollen and/or severe injury. During our study we recorded the % of cows scored with a visible hock injury (i.e. score = 2) and % with severe injury (hock scored = 3). As you can see from the data presented in Figure 2 the prevalence of hock injuries varied tremendously among regions, from 42% in BC, to 56% in CA, to 81% in NE. Although far less prevalent, we are also especially concerned with severe hock injuries which ranged from 2% in CA to 5% in NE, with BC intermediate. Although it is concerning that these injuries are so prevalent on some farms in each of the regions, equally promising is that in every region some producers were able to achieve good levels of success in keeping the % of cows affected low.

Cows in CA and the NE were also recorded for swollen knees (carpal joint) (Figure 3); injuries were recorded as present (evidently swollen joint with or without skin damage) or absent. This injury was rarely observed (less than 1% of cows affected) in CA, but unfortunately swollen knees were relatively common (23% mean prevalence) in NE (von Keyserlingk et al., 2012).

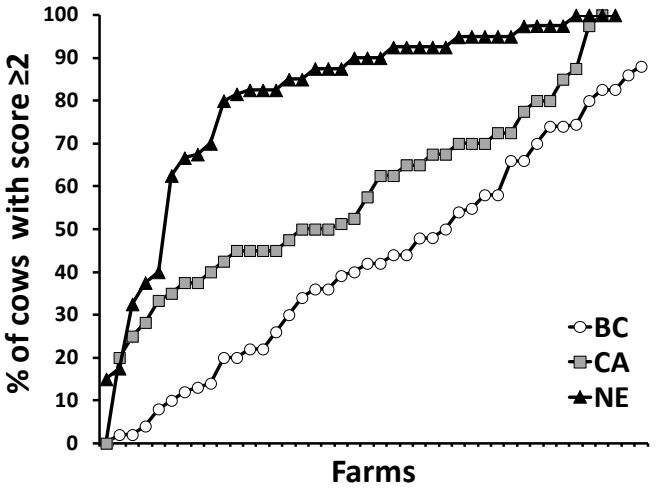
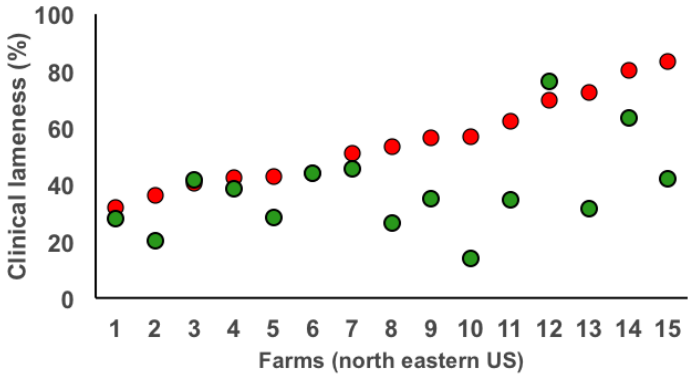


Figure 2. Hock injuries on farms in British Columbia (BC), California (CA) and North Eastern US (NE); farms are ranked from lowest to highest (see von Keyserlingk et al., 2012).

Figure 3. A lactating Holstein cow identified as having a swollen knee (photo credit UBC Animal Welfare Program).

Our ultimate goal is to motivate farmers to address the measures that are shown to be a challenge for them during the benchmarking process. To date we have only completed one study that addresses this issue. We were given the opportunity to return to farms in the NE region of the United States that had taken part in our previous benchmarking study summarized by von Keyserlingk et al., (2102). Please note that this was a convenience sample, as the farmers we visited in this study had asked that we come back to provide them with update information and thus they were likely highly motivated to reduce lameness and hock injuries on their farms. Lameness rates improved on 13 of the 15 farms included in this study, with prevalence often reducing more thatn 10% (Chapinal et al., 2014; see Figure 4a). Even more impressive still was the improvement in hock lesions (Figure 4b) where almost all farms improved. Collectively, our work undertaken to date suggests that the benchmarking process should be approached as an iterative process: the initial assessment followed by tailored changes on a farm, and then followed by a re-assessment, followed by new changes, etc., allowing farmers to make decisions on what works best on their farm, evaluation of their implemented changes and then evidence of how well their changes meet their management goals.

A)



B)

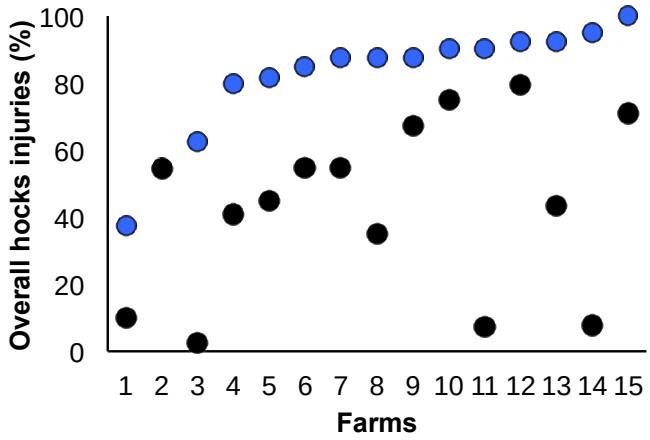


Figure 3.Prevalence (%) of A) clinical lameness and B) clinical hock injuries in 15 freestall herds in Northeastern United States in two consecutive farm assessments. Green (Panel A) and black (Panel B) circles designate the first assessment for lameness and hock injuries, respectively. Farms are sorted by prevalence at the first assessment (see Chapinal et al., 2014b)

Risk Factor Analyses

Our second objective with this on farm work is to use the data to identify risks for lameness and lesions. We are able to do this within different regions. For example, in British Columbia we found that the mean prevalence of severe lameness (gait score 4 or 5; Flower and Weary 2006) was higher on farms where cows were on mattresses (9% of cows severely lame) versus farms that using deep-bedded cubicles (4% of cows severely lame) (Ito et al., 2010). In the north eastern United States, where many farms used mats or mattresses with little bedding, the occurrence of lameness was reduced by half on farms using deep bedding or providing dry cows access to pasture (Chapinal et al., 2013). In California, all farms used deep-bedded cubicles and almost all farms provided outdoor access (typically to a well-bedded dry lot). Likely because of these conditions, rates of severe lameness were much lower in this region (Chapinal et al., 2013). Within the California farms, lameness was lowest on farms where cubicles were kept clean (i.e. not contaminated with feces) and on farms

that used rubber in the alley leading to the milking parlor. These results illustrate that when farmers work towards eliminating one risk factor (e.g. by changing from mattresses to deep bedding) new limiting factors are identified (such as the benefits of rubber flooring; Chapinal et al., 2013).

We also saw similar regional differences in risk factors associated with hock injuries. For instance in the NE, our work indicates that farms that provide cows with stalls that are deep-bedded and clean as well as providing access to pasture during the dry period are associated with lower prevalence of hock injuries. Our analyses also indicated that the use of a manure removal method other than automatic scrapers is important protective factor in this region. Interestingly, in CA where we all farms visited made use of deep bedding, we saw lower prevalence on farms with better stall management and those that did not overstock.

Conclusions

Benchmarking is a powerful method for promoting the adoption of practices that result in improved dairy cattle welfare (von Keyserlingk et al., 2012). This process involves providing individual farms with data from their own farm and averages from other farms in their region. Producers are provided confidential benchmarking reports that they and their advisors can use to make better-informed decisions on management practices and develop tailored strategies for improving the care and management of cattle on their farm. Equally important is the data set that emerges from this exercise, allowing researchers to identify practices and farm design features associated with high levels of success.

Acknowledgments

The research findings described above are the result of years of collaborative work and we gratefully acknowledge the many students and other collaborators that made this work possible. We are also grateful to the Natural Sciences and Engineering Research Council of Canada Industrial Research Chair program, with industry contributions from the Dairy Farmers of Canada (Ottawa, ON, Canada), British Columbia Dairy Association (Burnaby, BC Canada), Westgen Endowment Fund (Milner, BC, Canada), Intervet Canada Corporation (Kirkland, QC, Canada), Novus International Inc. (Oakville, ON, Canada), Zoetis (Kirkland, QC, Canada), BC Cattle Industry Development Fund (Kamloops, BC, Canada), Alberta Milk (Edmonton, AB, Canada), Valacta (St. Anne-de-Bellevue, QC, Canada), and CanWest DHI (Guelph, ON, Canada).

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Sickness behavior in lactating dairy cows[1]

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Introduction

The periparturient period or "transition" phase (generally accepted as the period beginning 3 weeks prior to calving and ending 3 weeks following calving) is one of the critical points in dairy production where risks to animal welfare are highest (von Keyserlingk et al. 2009; Proudfoot et al., 2012; Sepúlveda-Varas et al., 2014). During the transition period, cows face a number of stressors including diet changes and social regroupings, and the physical, hormonal and physiological changes associated with calving and the onset of lactation. One of the main challenges for transition dairy cows is a sudden increase in nutrient requirements to support the onset of lactation at a time when dry matter intake lags behind (Drackley, 1999).

Sickness in dairy cows can reduce production efficiency in three ways: by reducing milk production, reducing reproductive performance, and by shortening the life expectancy through increased culling rates. During the transition period dairy cows are vulnerable to metabolic and infectious diseases making early detection of disease particularly valuable at this time. For example, metritis is commonly diagnosed within the first few weeks after calving. This disease reduces milk yield (Rajala and Gröhn, 1998) and impairs reproductive performance (Opsomer et al., 2000, Melendez et al., 2004); reproductive status is likely the single most important factor influencing culling decisions on farms (Gröhn et al., 2003).

The majority of research on health issues in transition dairy cows has focused on nutrition, physiology and metabolism. Despite great advances in our understanding of these areas, the incidence of disease after calving remains high. Research has indicated that cows with lower feed intakes are at higher risk of metabolic and infectious diseases during the transition period. However, changes in feed intake must ultimately result from changes in feeding behavior. Feeding behavior has been shown to predict morbidity in feedlot steers (Sowell et al. 1998 and 1999) and may be similarly useful for prediction of disease in transition dairy cows.

The objectives our transition cow research program are to gain a better understanding of the behavioral changes that occur during the transition period, to evaluate the relationships between behavior and intake during this period and how these measures relate to health status after calving. This conference proceedings reviews nearly a decade of research by our research group that shows how feeding and standing

[1] This is an updated version of a conference proceedings that was initially written for the Western Canadian Dairy Seminar in 2011.

behavior change over the transition period and how knowledge of behavior changes around calving can be used to identify cows at risk for disease (specifically metritis and lameness).

Feeding and Standing Behavior during Transition

In our first study we investigated the changes in feeding and lying behavior of 15 transition dairy cows monitored from 10 d before until 10 d after calving (Huzzey et al., 2005). The daily time spent feeding was variable during the period before calving, but averaged 87 min/d. After calving the average feeding time dropped to 62 min/d. This drop may be explained by an increased feeding rate due to the switch to a higher energy postpartum diet. After calving feeding time increased at a rate of 3.3 min/d, most likely reflecting the rapid increase in dry matter intake (DMI) that occurs during this period to support increasing milk production (Kertz et al., 1991; Osborne et al., 2002).The pre- and post-calving standing times determined in our study (12.3 and 13.4 h/d respectively) were in general agreement with the findings of other researchers (Krohn and Munksgaard, 1993; Haley et al., 2000) suggesting that standing time during the transition period is not much different than during other stages of lactation. Healthy cows stood on average for 12.3 and 13.4 h/d during the pre and post partum period, which is not much different than during other stages of lactation. There was a dramatic increase (80%) in the number of standing bouts from 2 days before calving to the day of calving (Huzzey et al. 2005). This result suggests that cows were more restless, likely due to the discomfort associated with calving, and suggests that special attention should be placed on cow comfort in the maternity pen. This may be particularly important for cows experiencing dystocia (Proudfoot et al., 2009b).

Feeding Behavior Predicts Metritis

Metritis is an important post-partum disease due to its negative effects on the reproductive performance of dairy cows. The incidence of metritis or endometritis varies among studies from 8 to 53% (7.6%, Grohn et al. 1995; 53%, Gilbert et al. 2005; 16.9%, LeBlanc et al. 2002). This variation is likely due to differences in the diagnostic methods used to classify uterine infections. On the average dairy farm disease detection is done by the veterinarian, but typically only during routine herd health checks, so in many cases early warning signs of disease go unnoticed until such time that the disease is advanced.

In two studies we assessed whether cows that became ill with metritis after calving behaved differently than healthy cows. In the first study, we followed 6 Holstein heifers and 20 Holstein cows housed in a free-stall barn, and divided them into a pre-partum and post-partum group. Although group size was kept constant, group composition was dynamic as animals moved between pens as they progressed though the transition period, as is typical of many commercial situations. An electronic feeder was used to continuously monitor the feeding behavior of

individual cows over the course of the study, and this data was used to estimate average daily feeding time. After calving the cows were examined for metritis every 3 ± 1 d, based on rectal body temperature and condition of vaginal discharge. Vaginal discharge (VD) was assigned a score from 0 - 4 based on a scale adapted from Dohmen et al. (1995). As there is disagreement in the literature concerning which diagnosis criteria constitutes a case of metritis, 2 classifications were employed. Animals were classified as metritic if they showed a VD ≥ 2 plus fever (≥ 39.5˚C within 3 d before observation of VD ≥ 2) or acutely metritic if they showed a VD=4 plus fever (Urton et al., 2005).

Of the 26 cows used in this study 18 cows (69%) experienced some degree of pathological discharge (VD≥2) with a range of onset from 3-15 DIM. When we compared the feeding time of these cows beginning 2 weeks before calving, there were clear differences. Cows diagnosed with metritis/acute metritis spent less time feeding during both the pre- and post-calving period compared to healthy cows.

Other work has shown that these changes can also be useful in detecting illness in dairy cattle, especially during the transition period when cows are particularly vulnerable to metabolic and infectious diseases. Figure 2 illustrates how patterns of feed intake differ for healthy cows and cows diagnosed with metritis. The most dramatic differences in the diurnal feeding pattern occur during times of highest bunk attendance between 0600 and 1800 h.

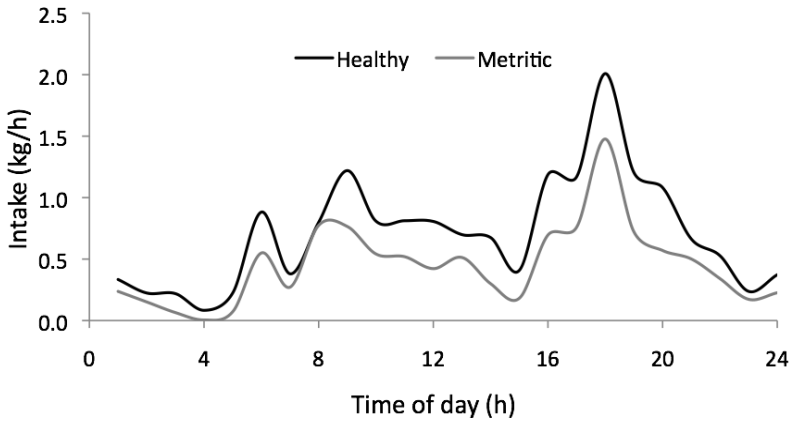

Figure 2. Diurnal feed intake of cows that remain healthy and cows diagnosed with clinical metritis after calving (Healthy n = 45, Metritis n = 22) from 5 to 10 d after calving (see review by von Keyserlingk and Weary 2010)

In a follow up study, Huzzey et al. (2007) recorded the dry matter intake (DMI) of 101 cows from 14 days before calving to 21 days after calving.

Cows that developed metritis or acute metritis ate less than healthy cows in the pre-partum period, up to 3 weeks before the disease was diagnosed. Feeding time was also measured and showed the same pattern. With every 10-minute decline in feeding time in the pre-partum period, the odds of cows becoming ill doubled.

The results of our research complement other studies that have examined the relationship between feeding behavior and health. Hammon et al. (2006) reported lower DMI, relative to healthy animals, during the 2 week period before calving for cows that went on to develop puerperal metritis. Quimby et al. (2001) worked with feedlot steers and found that reduced feeding behavior can be used to detect morbidity 4 days earlier than identification by pen riders. This work provides evidence that reduced feeding during the period before calving increases the risk of cows being diagnosed with metritis after calving. However, whether a reduction in intake and feeding time before calving is a cause of metritis or an effect of something else going on during the prepartum period, is not known.

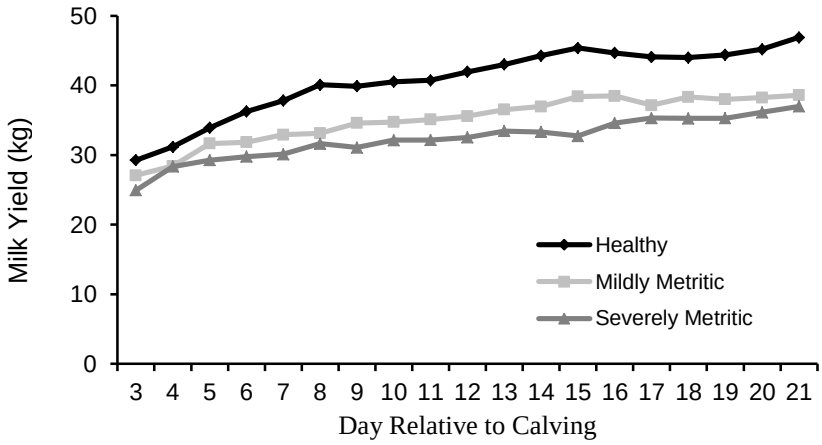

Figure 3. Average daily milk yield (kg) of healthy (n=23), mildly metritic (n=27) and severely metritic (n=12) Holstein dairy cows from 13 d before until 21 d after calving (adapted from Huzzey et al., 2007).

Long-term costs of metritis are often more difficult to quantify than short-term costs, yet may be much greater, due to poor reproductive performance and potentially culling the animal. We have estimated that cows with postpartum metritis produced less milk than healthy cows up to 20 wk into lactation, and cows that lasted 305 d lost about 1200 kg of milk over their lactation (Wittrock et al., 2011). Cows in this study with postpartum metritis were also twice as likely to be culled – probably as a combination of having lower milk yields as well as poor reproductive performance, since these are two of the most important factors that influence the decision to cull a cow (Figure 3).

Feeding behavior can also predict metabolic disease. In a follow-up study to the metritis work, Goldhawk et al. (2009) found that cows with low pre-partum intakes were more at-risk for subclinical ketosis after calving. Cows that later developed ketosis ate less, spent less time eating and were less

likely to be socially engaged at the feedbunk up to 2 weeks before calving.

Aside from the work we have undertaken on metritis and subclinical ketosis, we have also been interested in identifying risk factors that identify cows at risk for lameness. Historically, lameness has not been thought of as a transition cow disease, likely because most cases of lameness arise months into lactation. Recent work has provided evidence that physiological and behavioral changes during transition can increase the risk of lameness later in lactation (Knott et al., 2007; Cook and Nordlund, 2009; Proudfoot et al., 2010).

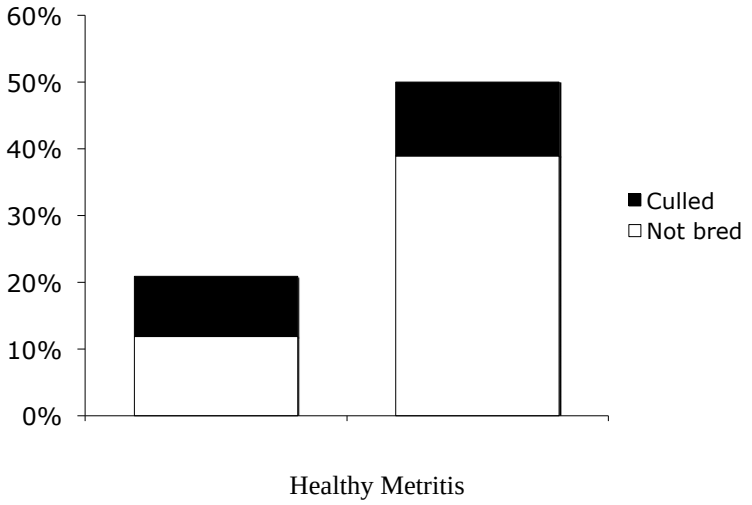

Figure 4. Cows that were diagnosed with metritis are twice as likely to be culled (see Wittrock et al., 2011)

Many severe cases of lameness are caused by claw horn lesions (e.g., sole ulcers and white line lesions), which take 8 to 12 weeks to develop. Thus, a sole ulcer that is diagnosed 12 wk after calving likely began developing, or was triggered, during transition. The high incidence of lameness cases after calving illustrates the need to focus on the transition period to prevent both infectious and metabolic diseases directly after calving, as well as lameness cases months after calving.

We assessed whether transition cows at risk for lameness behaved differently than healthy cows (Proudfoot et al., 2010). Data loggers were fixed to the hind legs of cows and measured standing time 2 weeks before to 3 weeks after calving. Cows were then hoof scored monthly until 15 weeks in milk. Thirteen cows developed sole ulcers or severe sole hemorrhages between 7 and 15 weeks after calving. The standing behavior during transition of these cows was compared to 13 healthy cows. Cows with lameness after calving stood longer in the pre- and early post-partum period than healthy cows. Most of this difference was driven by higher time

spent half in the stall (i.e., "perching" with the 2 front feed in the stall and 2 hind feet in the alley).

Another line of work undertaken by our students has shown us that dairy cows housed indoors still seek isolation when provided the opportunity when parturition approaches (Proudfoot et al., 2014a) but equally interesting is that they show similar isolation seeking behavior in the days before illness diagnosis (Proudfoot et al., 2014b). This finding, combined with the reductions in social behaviour in response to illness (Sepúlveda-Varas et al., 2016; review by Proudfoot et al., 2012), may be an adaptive response to illness, so allowing ill cows to find some seclusion when ill may also aid in disease recovery.

Ample evidence now suggests that detailed knowledge of behavior can help identify cows at risk for metritis, sub clinical ketosis and lameness in transition dairy cows. This information can also guide the development of management practices that can 1) help detect disease early and 2) help prevent disease by addressing management challenges during transition that might influence these risky behaviors (i.e., decrease feed intake and increase standing time).

Social behavior may play an important role in disease susceptibility in dairy cattle. We have observed that during the week before calving cows that go on to develop severe metritis displace others from the feed bunk less often then cows that remain healthy. In addition, during this period before calving, cows that later become ill spend less time eating and consume less DM during periods when cows are highly motivated to access the feed [i.e. following the delivery of fresh feed, when feed palatability and quality are at there highest (DeVries and von Keyserlingk, 2005)]. Because bunk occupancy is also at its highest during these peak feeding times, it appears that cows that later develop severe metritis lack the motivation to compete for access to feed during these periods and this may indicate that these cows are the socially subordinate individuals in the group.

During the transition period numerous changes occur including frequent mixing and regrouping of animals. Socially subordinate cows may be unable to adapt to these frequent social restructurings and consequently these cows may respond by reducing their feeding time and DMI and increasing their avoidance behavior in response to social confrontations. These behavioral strategies may put these cows at greater risk for nutritional deficiencies that impair immune function and increase susceptibility to disease. Future work in this area should focus on gaining a better understanding of individual responses to management practices such as regroupings during the transition period, and how these management changes influence a dairy cow's susceptibility to disease after calving.

Accommodating the sick cow
Feeding behavior

A number of management practices can influence the feeding and standing behavior of transition dairy cows. For instance, overstocking the feed bunk increases standing time waiting to gain access to the feed bunk (Huzzey et al.

2006), reduces the amount of time cows spend feeding, and reduces intake in healthy transition cows (Proudfoot et al., 2009a). When cows are given generous space to feed, subordinate animals are most likely to benefit (DeVries et al., 2004). Grouping strategy may also influence feeding behavior; regrouping or mixing cows into new social groups can decrease feed intake as well as the number of aggressive interactions in which the new cow is involved (von Keyserlingk et al., 2008). Stimulating feeding can be done using a frequent delivery of fresh feed (DeVries et al., 2005); cows fed 4 times per day spend about 30 min more time eating than cows fed once per day.

Standing behavior

A high standing time could suggest a deficit in the cow's environment; for instance, cows housed in pens with insufficient number of lying stalls, low bedding, wet bedding, or restrictive neck rails spend more time standing than those with dry stalls and less restrictive neckrails (Tucker and Weary, 2004; Fregonesi et al., 2007; Fregonesi et al., 2009). Cows that perch with their 2 front feet in the stall during transition are also at increased risk for lameness (Proudfoot et al., 2010); this behaviour has been linked with restrictive stall design (Tucker et al., 2005; Fregonesi et al., 2009).

Moving the neckrail further from the curb reduces perching behaviour and can reduce lameness cases (Bernardi et al., 2007). Although this practice comes at a hygiene cost (cows standing with all 4 feet in the stall will defecate and urinate more into the stall) there is no clear evidence that it increases the risk of mastitis. However, if this practice is utilized after calving, it is recommended that stalls be cleaned often, as fresh cows are at high risk for mastitis.

Regrouping

Dairy cows are also forced to adapt to numerous management challenges during the transition period. On typical North American dairy farms the transition from pregnancy to lactation is marked by several social re-groupings and changes in diet. The first group change, approximately 3 wks before the cow's expected calving date, allows cows to be fed a diet with higher energy and nutrient levels. There is evidence, however, that regrouping has negative consequences on both behavior and production. Work by our own group showed increased aggression and reduced milk production in the days immediately following regrouping (von Keyserlingk et al. 2008). One of our studies also provides evidence that cows that were moved to a new pen and mixed with new cows were particularly affected by the regrouping (Schirmann et al. 2011).

Conclusions

Transition cows need adequate rest, appropriate nutrient intake, and a relatively stable social environment to stay healthy. Several risk factors for infectious and metabolic diseases postpartum and lameness in the few months after calving are related to housing and management. An optimal transition cow environment facilitates ample feed intake by reducing competition for feed and social regrouping, as well as accommodates these vulnerable cows with clean, dry,

well-bedded, and unrestrictive standing and lying spaces.

Acknowledgements

We thank the many graduate students of the University of British Columbia's Animal Welfare Program whose passion and hard work has made our contributions to the field of animal welfare possible. The Animal Welfare Program is supported, in part, by Canada's Natural Sciences and Engineering Research Council Industrial Research Chair Program (Ottawa, ON, Canada) Industrial Research Chair Program with industry contributions from the Dairy Farmers of Canada (Ottawa, ON, Canada), British Columbia Dairy Association (Burnaby, BC Canada), Westgen Endowment Fund (Milner, BC, Canada), Intervet Canada Corporation (Kirkland, QC, Canada), Zoetis (Kirkland, QC, Canada), BC Cattle Industry Development Fund (Kamloops, BC, Canada), Alberta Milk (Edmonton, AB, Canada), Valacta (St. Anne-de-Bellevue, QC, Canada), and CanWest DHI (Guelph, ON, Canada).many others listed on the Animal Welfare web site at http://www.landfood.ubc.ca/animalwelfare.

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Scientific assessment of cow comfort

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Introduction

What does the term 'cow comfort' really mean? When we hear dairy famers use this term we understand two different sorts of meaning. The first is very general, and roughly corresponds to what in the academic literature is termed 'animal welfare', meaning that the animal is doing well in every sense that is important to it – that it is to say it is healthy, happy, and able to perform those natural behaviors that are important to it (Fraser et al., 2007; see von Keyserlingk et al., 2009 for an application of these ideas to the dairy system). Dairy farmers often use the term cow comfort more specifically to relate to how well the cow fits and thrives in the environments we build for her, including the indoor environments in which many dairy cows spend most of their lives. But even this more specific meaning can cover all the ways she interacts with the housing and management systems designed for the cow, ranging from the milking parlor to the trimming chute. This talk will focus more specifically on how design and management features of the freestall barn, with a special focus on the lying stall, although as you will see addressing even this narrow conception of cow comfort requires some discussion of the broader concepts around animal welfare and even what conditions can be considered to be required to provide a good life for these animals.

Our research group has worked for some 20 years to identify methods of improving the welfare of dairy cows. Projects vary depending upon farmer and student interest, funding, etc., but one common feature is that we attempt to address real world problems faced on dairy farms, and to provide solutions that could be adopted by at least some farms.

For many of us who work with dairy cows, lameness is considered perhaps the greatest threats to dairy cow welfare; lameness is painful, long lasting and prevalent. We believe that cow comfort is important in its own right, and that many cases of lameness could be prevented by housing cows in barns that are more comfortable for the animals. We will address lameness, and how aspects of stall design and management can contribute to lameness, in a companion paper. Our aim here is to describe some of the main scientific approaches to assessing the more specific meaning of cow comfort, and review examples from our own research showing how freestall barn design and management can affect the cows.

We propose that the cow comfort assessments can take four main approaches: 1) observations of unnatural and injurious behaviors, 2) the measurement of injuries caused by the housing system, 3) the measurement of cow preferences including their motivation to access different housing options, and 4) the measurement of behaviors

related to comfort, including standing and lying, when housed in different environments. Below we address each of the approaches in more detail.

Unnatural and injurious behaviors

A very important and perhaps under-appreciated role for veterinarians and other dairy professionals that visits many commercial farms is to provide a 'fresh pair of eyes' for the producer. It is normal that we become habituated to things around us, good and bad, so that it can become hard for people to spot problems on their own farms. This 'farm blindness' can affect us all. For example, we only became aware of the prevalence and seriousness of hock lesions on our own farm after these after a visitor photographed the injured legs of our own cows and sent the photos to the Dean of our Faculty. So cow comfort assessments can begin with something as simple as visiting a farm with a fresh set of eyes, and taking the time to see how the cow interacts with her environment.

We suggest that the best place to start by looking for evidence of unnatural behaviors. Unnatural is not the same as abnormal; on some farms behaviors that unnatural behaviors can be normal. Examples include lying down outside of the stall in the alley or elsewhere in the pen, 'dog sitting' in the stall, lying half out of the stall, or perching in the stall, with the front legs on the stall surface and the bag legs in the alley (Figure 1). We will return later to why some of these behaviors may also threaten the health of the cow, but for now it is enough to recognize these as unnatural, and to begin the trouble shooting process to identify the factor or factors that is resulting in the cow behaving in these ways.

Some unnatural behaviors may increase the risk of injuries to the cow, but even perfectly natural behaviors can lead to injuries in poorly designed and managed faculties. Again, taking the time to carefully observe the cows and how they interact with their facilities can provide indications of a problem. For example, the stall partitions and other hardware we use in freestall pens are designed to position the cow in the stall so that she is less likely to defecate on the stall surface. Ideally the cow should not contact this hardware at all, so if you see the cow hitting parts of the stall when she gets up and lying down this should be considered a problem. Even if you don't see the contact you can diagnose this indirectly, by taking the time to look at this hardware from the cows perspective. Do you see shiny (polished) metal surfaces? If so cows are likely in regular contact with that surface, perhaps with enough force to cause them injury.

Injuries caused by the housing system

Perhaps the most obvious example of poor cow comfort is when the housing systems we provide our animals cause them injuries. Unfortunately, such injuries are all too common.

Of all the injuries caused by freestall housing perhaps the most common, and our opinion the easiest to solve, is the hock lesion. Hock lesions are any skin injury on or around the carpal joint. Most typically these appear on the lateral surface of the carpal joint, but lesions also occur on the medial

surface and on the dorsal, medial and ventral surfaces of the tuber calcis (Weary and Taszkun, 2000). Unlike hoof lesions that require a freshly trimmed hoof to observe and that are difficult to score consistently, hock lesions can be easily observed whenever the cow is in the milking parlor, and producer friendly scoring systems are available that allow these lesions to be scored consistently (e.g. Hock Assessment Chart for Cattle developed by Cornell Cooperative Extension; www.ansci.cornell.edu/prodairy/pdf/hockscore.pdf ; where 1 =healthy hock, 2=bald area on the hock without evident swelling, and 3=evidently swollen and/or severe injury). At the herd or group level prevalence can be calculated using the % of cows scored with a visible hock injury (i.e. score = 2) and the % with a severe injury (hock scored = 3).

The results of a number of studies (e.g. Weary and Taszkun, 2000) have shown that the risk of hock injuries can be much reduced by changes in housing. Specifically, these lesions are much less common on farms with well-bedded stalls, meaning copious quantities of dry bedding. Farms using little or no bedding typically have high rates of hock injuries bedded surfaces like mats and mattresses.

In one cross-farm study we visited dairy farms in the north-eastern United States (New York, Vermont and Pennsylvania) and in California (Barrientos et al., 2013).

Figure 1.Cows ‘perching’ in the stall, with the front hooves on the stall surface and the rear hooves in the alley (photo credit Animal Welfare Program).

In the farms in the north-eastern United States many farms used poorly bedded mattresses or mats, but farms with deep-bedded stalls had a much reduced the odds of hock lesions (Figure 2). Other management practices linked to reduced hock injuries included dry bedding and access to pasture during the dry period.

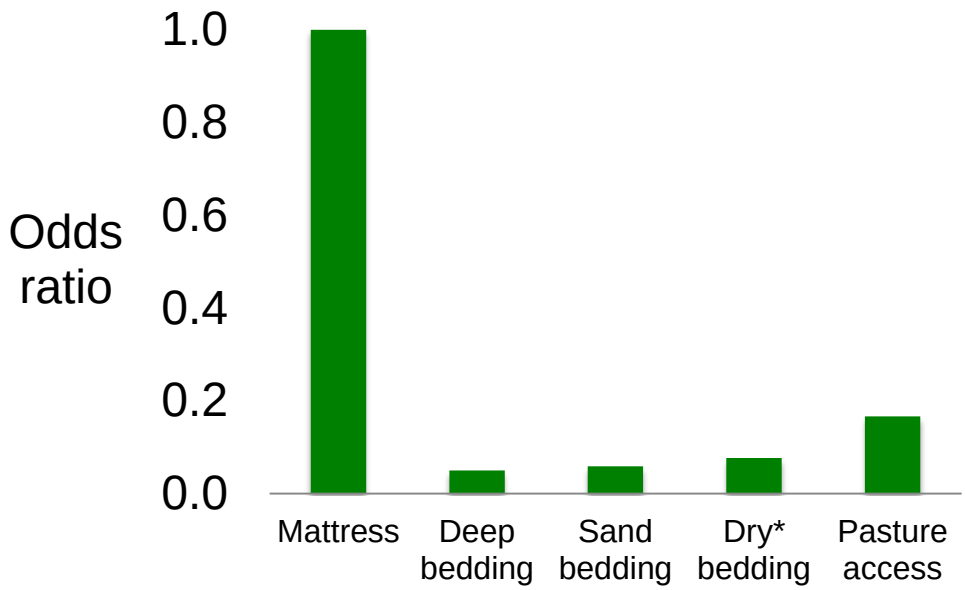

Figure 2.Odds of hock injuries on farms in the north-eastern United States using different management practices. Farms with deep-bedded stalls normally bedded with sand, and sand stalls tend to have a relative dry stall surface (*DM > 84%), so these protective factors should not be considered independent. Data are from Barrientos et al. (2013).

In California (where all the herds assessed had access to deep bedding) hock injuries were far less common, and farms with well-maintained stalls (i.e. level in the stalls) had the lowest rates. Thus across regions, farms that use well-maintained, deep-bedded stalls had fewer cows with hock injuries. Access to deep-bedded stalls (and well-bedded outdoor dry lots) may also explain the low prevalence of cows with swollen knees in CA versus the NE.

In our view, these results are so clear that the render the issue hock lesions essentially solved: we know that these lesions can be prevented by keeping cows on well-bedded lying surfaces. Indeed, farms that make such changes in the lying surface and bedding management can achieve impressive reductions in lesion prevalence (Chapinal et al., 2014). What is

required now is to get this knowledge out onto dairy farms so that these changes are made and hock lesions become a problem of the past.

Other types of injuries still require study, but we believe should also be relatively easy to trouble shoot. In our experience swollen front knees are remarkably common and our sense is that this issue is due to inadequate cushioning of the stall surface, with lesions most common on concrete and hard rubber mats, or poorly designed mattresses and waterbeds. Thus access to deep-bedded stalls (and well-bedded outdoor dry lots) may also explain the low prevalence of cows with swollen knees in California versus the north-eastern United States. Neck lesions can also be common on some farms (often associated, we believe, with poorly designed feed barriers); these too deserve attention. We conclude that recording lesions provides a remarkable straightforward and important method in cow comfort assessment, and can provide veterinarians and others some success when helping farmers address issues with cow comfort on their farms.

Preference and motivation

Allowing animals to choose between different options, and recording their choices, can provide a straightforward way of addressing issues related to cow comfort. The basic idea of allowing animals to 'vote with their feet' is one of the oldest and most important techniques in animal welfare science, despite a number of well-known limitations to the method (Fraser and Nicol, 2011).

We have used preference tests to examine a number of housing factors relevant to cow comfort. Preferences for lying areas seem to be especially affected by the quality of the lying surface. For example, cows strongly prefer to lie down on dry bedding (Fregonesi et al., 2007), and chose to lie down in stalls with deep bedding versus on poorly bedded mattresses (although this preference is also affected by familiarity; Tucker et al., 2003). Cows also choose to avoid lying areas with hardware that impedes their ability to lie down and stand up, for example avoiding stalls with restrictive neck rail barriers (Tucker et al., 2005) and preferring an open lying area (with no stall partitions) to conventional freestalls (Fregonesi et al., 2009). Interestingly, the suitability of the surface seems to trump other factors in the cows choice of where to lie down; cows will choose to lie down in a conventional freestall rather than an open bedded area with wooden barriers that rise only slightly from the lying surface (Adabe et al., 2015).

The preferences of animals will vary depending upon the behavior that they are most motivated to engage in. For example, cows search for both a comfortable area to lie down, and for a comfortable area to stand upon. Like the lying area, cows will generally prefer a dry, soft area for standing. Cows could use the freestall for both lying and standing, but stalls are typically designed to make it hard for cows to stand fully on the stall surface; moving the neck rail makes it easier for the cow to stand in the stall, and thus avoid the wet, hard, concrete surface outside of the stall (Fregonesi et al., 2009). Preferences for a dry, soft standing surface, as well as for an

unrestricted lying surface, likely explains why cows also show a preference for pasture (versus staying inside the freestall barn) when this choice is made available (Legrand et al., 2009). Interestingly, this is a partial preference, as cows choose to go outside especially at night (so long as weather conditions are suitable) but tend to stay inside during the day (Figure 3). We believe that the preference to stay indoors during the day is driven by the cows' motivation to avoid exposure to the summer sun and flies, and their motivation to consume the high-energy mixed ration, fed fresh during the day.

One criticism of preference studies is that it is hard to know how important it is to the animal to be able to access their preferred option. One way to assess the strength of preferences is to compare motivation for one thing against another. In a now classic study, Metz (1985) found that cows were willing sacrifice eating for the chance to lie down, even if animals had been restricted from both lying and feeding for 3 h before the test. Another way of assessing the strength of preferences is to have animals perform some type of work to access a preferred resource. For example, cows could be trained to push upon a weighted gate to gain access to food, to a comfortable lying area, or to pasture, and we can measure the amount of weight that cows are willing to push as a measure of their motivation to access each the resources. In current work at UBC we are developing these tests.

In addition to measuring motivation directly with the motivational tests described able, we can also develop indirect tests based upon the way that cattle use the resources we provide to them. For example, we can measure how often cows choose to lie down or stand up in different areas, and the amount of time that they spend engaged in these activities – we turn to these types of usage measures below.

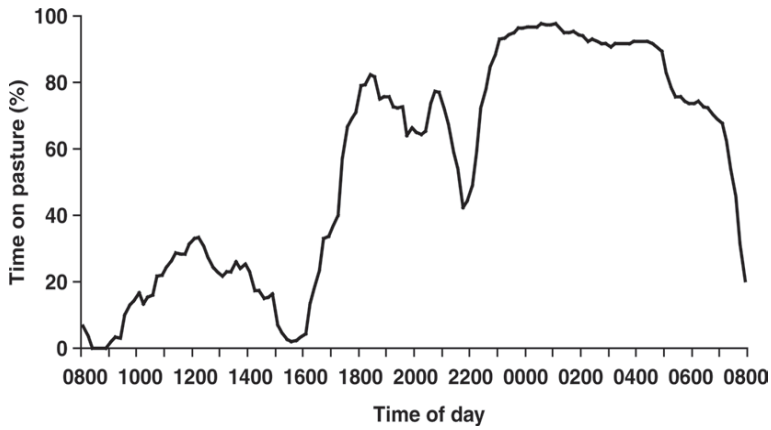

Figure 3. Cows spent the majority of the nighttime outside on pasture but spent the majority of the daytime inside the freestall barn. Cows were milked at approximately 0800 and 1500 h. Researchers associate warm daytime temperatures with the cows' preference for staying in the barn during the day. Adapted from Legrand et al., 2009.

Standing and lying behaviors

In many studies using conducted at our own research farm we have tested various design and management features to see how these affect cow behavior (e.g. Abade et al., 2015; Bernardi et al., 2009; Winkler et al., 2015). For example, in a series of studies we have found that cows spend more time lying down in stalls with deep, dry, and well maintained bedding (Tucker at al., 2009; Fregonesi et al., 2007; Drissler et al., 2005).

The gold standard for measuring these behaviors is continuous, 24 h observation. This type of data can be collected using video cameras, but in practice setting up cameras in barns can be difficult, especially to achieve the appropriate coverage of the important lying, standing and feeding areas, etc. In addition, this video still needs to be watched and scored by an observer, requiring an enormous number of hours to score a number of cows over a number of complete days. Now several types of electronic monitoring device are available that can automate the recording of some behaviors. For example, we have found that the Hobo data loggers can be used to accurately record the total time animals spend lying down, the number of lying down and standing up events, and the duration of each of these lying and standing bouts. Validation data has been published for dairy cows and calves, and most recently we have also published validation data for the use of these devices in dairy goats (Zobel et al., 2015).

With this type of automated monitoring it becomes relatively easy to measure the effects of different types of housing options on these behaviors. We have found that the preferences described above generally correspond well to these usage measures. For example, cows prefer stalls with copious amounts of well maintained bedding and also spend more time lying down in these stalls even when they are restricted only a single option. In one study we experimentally manipulated the leveling of sand bedding in the stall (Drissler et al., 2005) and found that cows showed a linear, dose-dependent response to bedding maintenance, with lying times declining by more than 2 h when stalls are poorly maintained (Figure 4).

In a series of experiments we have found changes in lying times varying with the way in which stalls are configured and managed. However, lying times also vary greatly among cows, so sensitive tests for treatment differences require that tests be done within cow (i.e. testing each animal in each condition, so as to use the cow as her own control).

In some cases, the number and structure of lying bouts can be more relevant than the total time spent lying. In recent work we have become especially interested in the design and management of facilities for more vulnerable cows, including sick cows and cows around the time of calving. In one study we kept cows in calving bens with different types of stall flooring, and found that cows engaged in more transitions between standing and lying when kept on deep bedded surfaces in comparison with rubber mats, especially near the time of calving when the frequency of standing and lying down movements typically peak (Campler et al., 2014).

We suggest that the most can be learnt from a careful consideration of a number of behaviors relevant to how the animals use the facilities that we design and manage.

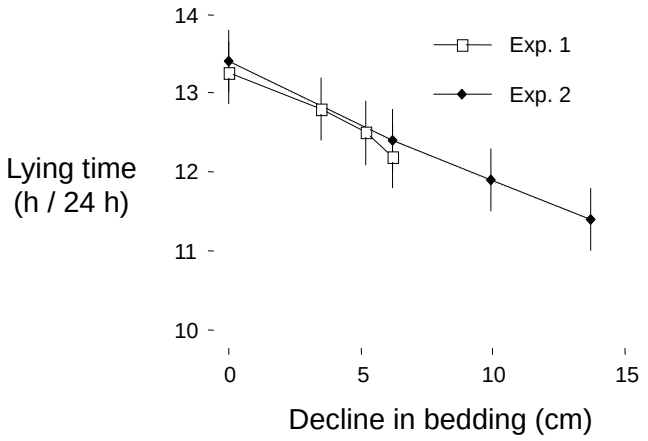

Figure 4.The lying time (h/24 h) for cows housed in sand-bedded free stalls, in relation to how well these stalls were maintained. Stall maintenance was varied experimentally to match the condition of stalls after they had been used for varying periods with leveling, with the baseline condition being a 0-cm decline in bedding depth (i.e. a level stall surface). In Experiment 1 and 2 assessed varying ranges in in stall bedding decline. Adapted from Drissler et al., 2005.

The way that different behavioral measures can be affected by a management factor is illustrated in by Winkler et al.'s (2015) work on the effects of stocking density. As expected, cows spent less time lying down when fewer stall were available (density varied from under-stocking at 75% to overstocking at 150% cows:stalls). More interestingly, these differences in lying time were most apparent at night when cows are especially motivated to lie down. When cows could not lie down in the stall they spent more time standing in the alley. Cows were also more likely to competitively displace each other from lying stalls when housed at higher densities, and the socially subordinate cows least able to displace others were those most likely to spend time lying down in the stall during the day time when other cows were active.

What next?

The science of cow comfort has seem amazing progress over the past decade, in terms of what to measure, how to measure this, and in terms of better identifying the design and management features that help provide a comfortable environment for housed dairy cattle. In terms of measuring cow comfort, we especially encourage veterinarians and other dairy professionals to focus especially on measures of cow injuries, as these are relatively easy to observe and much is

known about how these can be prevented on commercial farms. In terms of housing features we suggest a special focus on the bedded surface: comfort is perhaps most affected by the availability of copious quantities of clean, dry bedding. This review has focused especially on freestall housing, as this is the system that has been most studied both by our group and by other researchers. However, we encourage new work examining a broad range of alternative housing systems. We suggest that there are likely far more comfortable environments that we can design and management for our cows, but finding these options will require creativity and stepping beyond the conventional structures that we typically find on commercial farms today.

Acknowledgments

The UBC Animal Welfare Program is funded by NSERC's Industrial Research Chair program, with industry contributions from the Dairy Farmers of Canada (Ottawa, ON, Canada), British Columbia Dairy Association (Burnaby, BC Canada), Westgen Endowment Fund (Milner, BC, Canada), Intervet Canada Corporation (Kirkland, QC, Canada), Novus International Inc. (Oakville, ON, Canada), Zoetis (Kirkland, QC, Canada), BC Cattle Industry Development Fund (Kamloops, BC, Canada), Alberta Milk (Edmonton, AB, Canada), Valacta (St. Anne-de-Bellevue, QC, Canada), and CanWest DHI (Guelph, ON, Canada).

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Identifying and preventing pain and suffering in dairy cattle

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Introduction

People's concerns about the appropriate treatment of others (animals and humans) often place much importance on the prevention of pain. Causing pain to another individual is typically considered immoral, and failing to prevent pain (that can, reasonably be prevented) is almost as bad. But farmed cattle routinely experience pain, sometimes severe and long lasting, sometimes directly caused by the procedures we apply, and other times by ailments that they experience. Very often the pain experienced is not treated, despite the widespread availability of effective treatments. This chapter reviews research on pain assessment and prevention in cattle, describes a variety of methods to identify pain, discusses ways of treating common sources of pain, and ends with a discussion of how pain can lead to suffering in animals.

Pain assessment and prevention

Pain assessment is not always straightforward. The methods we use to assess pain in people will not necessarily apply to animals. For example, the gold standard in pain research on most humans is the verbal reports, but this is impossible in animals. We thus need to develop innovative ways of 'asking' animals indirectly about the pain they experience. For example, some non-verbal measures first developed for use in humans, like the facial expressions described by Darwin (1872), have shown promise in laboratory mice (Langford et al., 2010) and farm animals (Gleerup et al., 2015). Finding out what measures are useful in cattle requires research, as described below.

Responses to a noxious stimulus

The most obvious method of identifying responses useful in pain assessment is to record how the animal responds to a noxious stimulus that can reasonably assumed to cause pain. The response measures can be physiological or behavioral, but for the purposes of this paper we will concentrate on behavioral measures, in part because we believe that we can draw stronger inferences regarding pain from behavioral responses.

Cattle are often subjected to injuries that are likely to cause pain, meaning that pain responses are also relatively easy to observe. Consider, for example, hot iron dehorning. Dehorning (sometimes referred to as 'disbudding' when calves are young) is typically achieved in calves by cauterizing the tissue around the base

of the horn, thereby preventing any further horn development. The resulting burn injury is associated with a number of well-documented acute pain responses, including kicking, struggling, vocalizing, etc.

In addition to these intra-operative responses, calves show a number of responses to the pain that persists in the hours following the procedure. For example, some work has shown that calves show sensitivity to touch around the wounded area for up to 75 h after dehorning (Mintline et al., 2013). In addition to this heightened response to tissue palpation, calves show altered lying behavior, and increased wound directed behaviors including head shakes, ear flicks and head rubs (Faulkner and Weary, 2000).

One way to be more certain that these responses are specific to pain is to examine responses with and without analgesics. Ideally, animals are also tested in a sham procedure (for example, with exposer to a cold iron that causes no burn), again with and without a proven analgesic. The ideal pain response measures are those that change only in response to the painful injury without analgesia. Animals that are injured but also receive analgesia should show a reduced response (ideally similar to the sham baseline), and the analgesic on its own (when provided to the sham treated animals) should have no effect on the response measures. This type of approach to validation is described in more detail in Weary et al. (2006), and an example of the approach as applied to dehorning of dairy calves is provided in Figure 1.

In addition to documenting how cattle respond to pain, this type of research has been useful in identifying how best to mitigate the pain caused by such procedures.

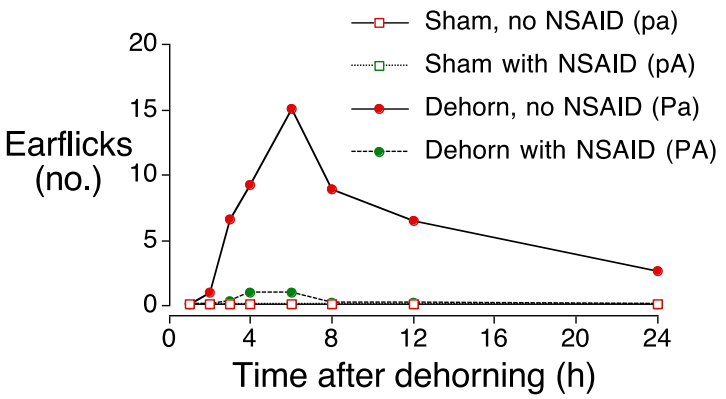

Figure 1.The number of ear flicks, per observational period, for calves assigned to one of four different treatments: dehorning with (PA) without (Pa) the provision of a NSAID, and sham dehorningwith (pA) and without (pa) effective the analgesic. Redrawn from Faulkner and Weary, 2000.

For hot iron dehorning, work by our group and others, has shown the benefits of a multimodal approach. Specifically, we recommend the use of a preoperative sedative to calm the calf and to facilitate the injections with a

local anesthetic that provides intra-operative pain control. And as illustrated in the example above, we also recommend the use of post-operative analgesics to control the long lasting pain responses that result from these burn injuries. The use of caustic chemicals (i.e. 'paste' dehorning) is also possible in young calves, but this method requires different means of pain control (Vickers et al., 2005). Regardless, it is clear that the public expects the dairy industry to provide adequate pain relief for the procedure (Robbins et al., 2015), and dairy industry organization are increasingly requiring that all farmers adopt pain mitigation protocols for dehorning. Dehorning is just one example of a routine surgical procedure causing pain. More work is needed on to develop methods of pain assessment and pain prevention protocols for other sources of surgically induced pain (Walker et al., 2011).

Even better that controlling the pain is to avoid painful procedures if possible. Thus the obvious long-term solution to dealing with the pain due to dehorning is to learn how to manage horned cattle, or to use genetically hornless (i.e. 'polled') sires. The latter has been the preferred option for much of the beef industry, with excellent genetics available in polled lines. The availability of polled sires is more limited for dairy breeds, but the situation is changing rapidly. With greater demand from farmers and veterinarians, the availability of excellent polled dairy sires will continue to grow.

Tail-docking is another example of a procedure for which abstinence is the preferred option. Tail docking became common in the 1990's and early 2000's, in large part due to the mistaken belief that docking cows would help keep animals cleaner, and thus also reduce the risk of intra-mammary infections. Study after study has now shown that tail docking has no such positive effect (e.g. Tucker et al., 2001; see also review by Tucker and Sutherland 2011). Indeed, farms that use this procedure have on average dirtier cows than do farms that do not dock tails (Lombard et al., 2010); this is likely because farms that dock their cows have a problem with cow cleanliness (likely because of poor housing and management on that farm), and they lack the skill or knowledge to adopt more useful approaches.

Responses to injury and disease

In addition to the painful injuries we cause to cattle (like dehorning, branding, etc.), cattle can experience naturally occurring injuries and diseases that cause pain. For naturally occurring ailments we often do not know when precisely the ailment develops or cures, but we can normally identify animals with and without the ailment, providing some basis for identifying measures associated with pain.

Of all the painful ailments experienced by dairy cattle, lameness is likely the most prevalent. Work by our group (von Keyserlingk et al., 2012) and others shows that prevalences often exceed 20% across a diverse range of regions. Lameness cases are often long lasting, likely making the effects of pain more difficult for the animals.

Changes in gait (i.e. the way animal's walk) provide one method of identifying lameness in cattle (Flower and Weary, 2009). Some changes in gait may be due to mechanical or other restrictions; for example, gait differs when cows walk to versus from the milking parlor (Flower et al., 2006), perhaps because the full udder interferes with the cow's ability to walk smoothly. But other changes in gait are likely due to the pain that the cow experiences from placing weight on the injured limb. One way to get a sense for how the pain causes gait changes is to compare animals with and without injury (Flower and Weary, 2006), and to examine changes in gait within lame cows when they are able to walk on a more comfortable walking surface (Flower et al., 2007).

As with the responses to the noxious stimulus described above, we are able to make more specific inferences regarding pain if we examine how these responses measures change when the animals are provided an analgesic. For example, Flower et al. (2008) measured changes in the gait score of lame cows when these animals were provided the recommended dose of the drug ketoprofen (3 mg/kg), half the recommended dose (1.5 mg/kg) and a nominal dose (0.1 mg/kg). The gait of the cows improved with treatment, especially at the higher doses (Figure 2). In a parallel study, Rushen et al. (2007) found that gait improved in cows following treatment with a local anesthetic in the injured limb. In addition to changes in gait score, Rushen and colleagues also examined two more objective measures: weight bearing on the injured limb (assessed directly using a load cell) and variability in the weight placed on the injured and contralateral limb; these measures also showed improvement with treatment with a local anesthetic, indicating that at least some of the variation in all three measures was due to pain.

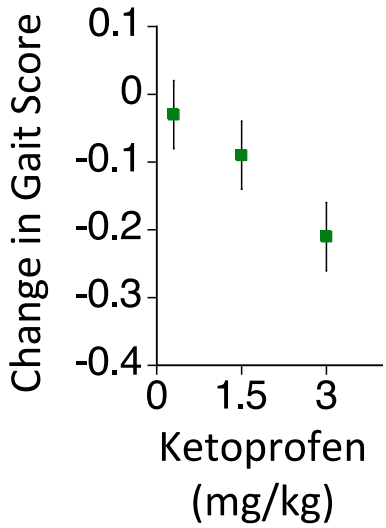

Figure 2.Changes in the gait of lame cows in relation to dose of the non-steroidal anti-inflammatory drug ketoprofen.Redrawn from Flower et al., 2008.

Another common disease that our group at the University of British Columbia (UBC) has worked upon is metritis. Like lameness, many cows experience metritis, especially in the weeks after calving. LeBlanc (2008) estimated that approximately 15% of cows experience clinical endometritis within the first 6 weeks after calving, and an addition 30% experience sub-clinical endometritis. Work on our own UBC herd, where we have carefully follow cows in the weeks after calving, has routinely found clinical metritis in more than 30% of cows (e.g. Huzzey et al., 2007; see also companion conference proceedings von Keyserlingk and Weary)..

We have been interested in using changes in behavior to detect diseases such as metritis that often go undiagnosed. For example, in addition to our work on metritis we have used changes in behavior to better detect animals with ketosis (Goldhawk et al., 2009; Itle et al., 2015) and mastitis (Sepúlveda-Varas et al., 2016). However, it is not clear to what extent these changes in behavior reflect a more general malaise (see Weary et al., 2009) and what, if any, are the result of pain.

In one recent study we have attempted to more directly assess the pain associated with uterine infection by measuring how cows respond to palpation of the affected organ (Stojkov et al., 2015). Back arch is frequently shown in animals experiencing abdominal pain, including in laboratory rats following laparotomy (Roughan and Flecknell, 2001), and is commonly used in the clinical assessment of lameness in dairy cows. In the study by Stojkov and colleagues, we monitored the back arch of dairy cows before and during palpation of the uterus. Cows showed a more pronounced back arch if they were metritic. This effect was clear during the palpation of the uterine wall, but also during the passive rectal exam, suggesting that that palpation of the uterus is not necessary to identify the more pronounced back arch response in sick cows. These results also suggest that metritis is associated with hyperalgesia in cattle, although further work using animals treated with analgesics is now needed to make stronger inferences on the role of pain.

What next – identifying and preventing suffering

As illustrated above, much is known about pain assessment in cattle, and this work has lead to important refinements in how to reduce the pain that cows experience. However, we have little basis for how to prioritize our work in pain detection and treatment. For example, should new work focus especially on painful and potentially painful procedures such as left displaced abomasum (LDA) surgery, teat removal, dehorning, freeze branding, hoof trimming, etc., or on ailments like lameness, metritis and mastitis?

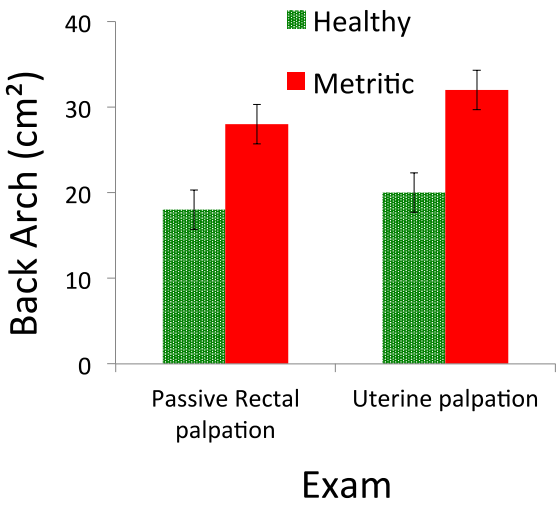

Figure 3.The extent of back arch shown by dairy cows diagnosed as healthy or metritic. Back arch was measured (in cm^2 from calibrated video) during a rectal exam with either a passive hand or during active palpation of the uterine wall. Redrawn from Stojkov et al., 2015.

Laws relating to animal welfare often refer to the concept of 'suffering', suggesting that preventing pain associated with suffering may be especially important. Unfortunately, scientific usage of the word suffering has tended to be weak; authors use the term simply as an embellishment (i.e. 'pain and suffering'), or to indicate that the animal is somehow aware of the pain (an issue rarely contested in cattle), or that the pain is long lasting or severe (duration and severity can be assessed independently, and there is no clear threshold for either factor allowing us to say when suffering might begin). Given that suffering has strong moral and legal implications, we have attempted to develop some criteria by which we might better identify cases of animal suffering (Weary, 2014).

Here we wish to focus on two main attributes often referenced in human reports of suffering related to pain. One is that the pain is associated with depression and the other is that pain is associated with the lack of control. We explain both aspects below and show how these could apply to our thinking of suffering in cattle.

Many of us experience at least some pain. For example, you might experience shoulder pain associated with repetitive strain from too much time using a keyboard and mouse? In many cases such pain will not affect your quality of life. You can still do everything you want to do; in no way does the pain take away from the joy of the good things in life. In other cases, however, pain can seriously diminish mood, and in the most serious cases patients become anhedonic. Thus one way to assess suffering in animals might be to see when pain results in low mood states consistent with depression in humans.

One way to assess mood states in human patients is to examine responses to neutral or ambiguous stimuli. For example, if you read the phrase 'the doctor examined the child's growth', what do you think? An optimistic assessment would be that the doctor was examining how well the child was growing, but a pessimistic assessment would be the doctor was examining the child's cancerous growth. This type of cognitive bias test can also be applied to animals, and some types of pain result in shifts in assessment consistent with low mood in animals.

In one study we trained calves to approach a colored video screen to earn a milk reward (Neave et al., 2013). For some animals, approaches to a red screen resulted in the milk reward, but approaches to a white screen were punished with a 'time out' when the screen would not turn on. In this way calves learned to approach the screen only when it was red. Once calves had learned the task they could then be presented with ambiguous screens (i.e. various shades of pink created by mixing the red and white colors). We found that calves would show intermediate responses to these cues, for example, approaching the mid-way shade of pink about half the time (Figure 4). However, in the hours after hot-iron dehorning (when calves are know to experience post-operative pain, as reviewed above), calves showed a pessimistic response bias, responding less frequently to the ambiguous shades, especially to those colors most similar to the negative screen. We also found evidence of cognitive bias in a second study examining calf responses before and after disbudding, and perhaps more interestingly, found a similar bias in the days after experiencing the emotional 'pain' associated with separation from the cow (Daros et al., 2014).

We argue that pain (both the physical pain from dehorning and the emotional pain associated with cow-calf separation) that results in changes in mood can be considered indicative of suffering, suggesting that treating or avoiding this type of pain may be especially important in our care for animals.

Finally, we would ask you to consider the issue of control and how this may affect the risk of suffering in animals. Not being able to control exposure to pain (e.g. ability to avoid the painful stimulus), not having the ability to control the duration and severity of the pain (e.g. the ability to access effective analgesics) and ultimately the fear that the pain will make you lose control over your sense of self, are often referenced in human descriptions of suffering, but we rarely consider the issue of control in the care and treatment of pain in animals. Compare, for example, two animals. One is restrained without warning and held down while it receives an injection. The second is trained (using a food reward) to voluntarily approach the handler for the same injection. The pain of the injection may be the same, but the animal's experience likely differs greatly.

Hoof trimming in cattle is thought to reduce the risk of hoof lesions associated with lameness, and to help lame animals recover. However, the trimming can cause pain, and the restraint and handling associated with

trimming is fear provoking and provides the animals with no control. According to the logic of our argument above, we suggest that routine trimming would be much less likely to result in suffering if animals were trained to voluntarily approach the trimmer. We encourage new research that examines pain in the context in which the pain occurs, with special focus on fear and control caused by the handling procedures.

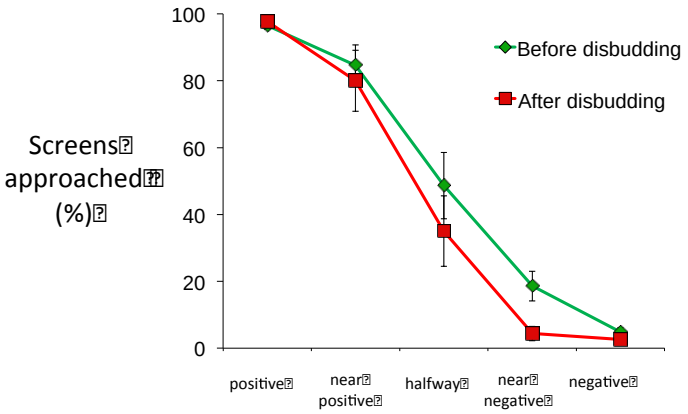

Figure 4.The % approach responses to positive and negative training screens and to three ambiguous colours intermediate to the training colors. Responses are shown separately before and during the 24 h after hot-iron dehorning. Redrawn from Neave et al., 2013

Acknowledgments

The UBC Animal Welfare Program is funded by NSERC's Industrial Research Chair program, with industry contributions from the Dairy Farmers of Canada (Ottawa, ON, Canada), British Columbia Dairy Association (Burnaby, BC Canada), Westgen Endowment Fund (Milner, BC, Canada), Intervet Canada Corporation (Kirkland, QC, Canada), Novus International Inc. (Oakville, ON, Canada), Zoetis (Kirkland, QC, Canada), BC Cattle Industry Development Fund (Kamloops, BC, Canada), Alberta Milk (Edmonton, AB, Canada), Valacta (St. Anne-de-Bellevue, QC, Canada), and CanWest DHwe (Guelph, ON, Canada).

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Lameness and pain in dairy cows: does it hurt and does it matter?

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Keywords
Pain; Cattle; Lameness; Analgesia; Pain recognition

Summary
This paper will consider some aspects of the ethical debate and scientific evidence that contribute towards our now widely held belief that animals do suffer pain. It will look at the effects of pain in cattle and review an effective integrated approach to the management of pain associated with lameness and other health problems in dairy cattle. Further to this it will consider how the perceptions and attitudes of humans towards pain in animals influence their actions and the likelihood of them taking action to relieve suffering.

Introduction

The 18th century philosopher Jeremy Bentham said of animals "…the question is not, Can they reason? nor, Can they talk? but, Can they suffer?". This widely used quote from Bentham describes the view that it is not necessary to judge animals' abilities by our own standards, i.e. whether they have speech or sophisticated decision making capacities, but that we should be most concerned about how they feel and whether they themselves are alright. The International Association for the Study of Pain (IASP) definition outlines that; [pain is] "an unpleasant sensory and emotional experience associated with actual or potential tissue damage" (International Association for the Study of Pain, 1983). It is important to note that this definition recognizes that pain has an emotional as well as physical component; this implies that some level of consciousness is required to fully experience pain in the way that humans do. Interestingly, despite the amount of value put on whether animals can have experiences akin to humans, it is only relatively recently that medical science has recognized that all adult humans experience pain to a similar degree regardless of race, gender and wealth. Even now the debate continues as to the levels of pain experienced by neonates. This uncertainty about whether neonates can experience pain illustrates the problem that we have to overcome when trying to understand whether non-human animals feel pain. It means that a) despite the obvious merit of exercising the precautionary principle it is still not standard practice in all neonatal care units to provide analgesia when dealing with poorly babies, and b) when examining the reason for this uncertainty about human neonates ability to suffer pain much of the problem seems to be that because young children cannot communicate

through language there is room for doubt as to their actual pain experiences.

In both humans and animals the apparent pain experience is not always consistent between individuals or with what might be expected. Severe fractures or wounds might be apparently pain free while what looks like the merest scratch may be reported or elicit behaviours akin to agony. In 1965 Melzack and Wall described seven inconsistencies in the behaviour of pain:

- The relationship between injury and pain is highly variable
- Innocuous stimuli may produce pain
- The location of pain may be different from the location of damage
- Pain may persist in the absence of injury or after healing
- The nature and location of pain changes with time
- Pain is not a single sensation but has many dimensions
- There is no adequate treatment for certain types of pain

While pain science gives us explanations, or at least partial explanations, for these inconsistencies dealing with the reality of this in a clinical situation, especially with non-verbal animals remains extremely challenging.

Evidence that cattle feel pain

The question of whether animals, in this case cattle, experience pain is clearly not straight forward to answer and a considerable weight of evidence has to be examined and considered before reaching any conclusion. Firstly, for cattle to experience pain the underlying physiological mechanisms of pain, the receptors, nerves and neurochemicals that are activated by noxious stimuli, should be similar to those of humans; which indeed they are. Further to this, the behavioural responses of the cattle to noxious stimuli should closely mirror those of humans; which they do. However, some people have then questioned whether animals [cattle] might experience the sensations of pain without actually suffering (Iggo, 1984). This might suggest that cattle have insufficient cognitive ability to allow them to experience pain or to put it another way "they might be too stupid to feel pain". Science continues to increase our knowledge about animal cognition and most who work in the field, while acknowledging that no definitive answers exist, point out that we have no proof that animals do not have subjective experiences; therefore the benefit of the doubt should be afforded to them (Nicol, 1996). To convince ourselves that cattle experience pain we might expect them to respond to the administration of analgesics, for example a lame cow should, as indeed it does, bear weight on the affected limb once it has received effective local anesthesia. However, it should also show a change in what might be termed "quality of life": This might take the form of either resting comfortably or alternatively becoming active and performing tasks, such as eating, which it was reluctant to do prior to receiving pain relief. The evidence for this is largely empirical but does exist. It appears when examining the available information that the balance tips towards the likelihood that cattle do

suffer pain and so we are ethically obliged to take steps to both prevent and properly manage their pain whenever possible.

Effects of pain and benefits of pain management

The term 'pain' is extremely generic and does not in itself convey the range of qualities of pain that may be experienced; stabbing, throbbing, burning, aching, grinding, piercing, radiating and tearing to name but a few. Cattle infected with Bovine digital dermatitis (BDD) show behaviours, repeated lifting and shaking of the affected limb, that seem to indicate that the lesion 'stings' under some circumstances. It is also notable that the IASP have also extended their descriptors of pain to include itching. In addition to the different qualities of pain, there is also a severity component which can range between unpleasant to down right intolerable for the sufferer. Pain also has ancillary effects that cause problems for both cattle and their carers.

Ancillary effects of pain include:

- Slowing down healing
- Causing a negative energy balance (at the very least through inappetance)
- Decreases in productivity
- Impairment of cardiovascular and respiratory function
- Aggressive behaviours
- Further associated problems (e.g. postural changes leading to muscle wastage or joint damage)

It is clear that pain in cattle is not only a serious animal welfare concern but that it should also be a cause of considerable management concern. The effective management of pain in cattle, using lameness as an example, can be divided into four phases (Whay, 2002):

1) **Recognition of pain:** Unless a painful clinical problem, for example lameness is detected no management action will follow. The earlier lameness is detected the more effective pain management will be. A study described by Whay and colleagues in 2002 (Whay et al. 2002) found that three out of four cases of lameness in UK dairy cattle were going unreported.
2) **Treatment:** Rapid and effective treatment will often immediately reduce suffering and will decrease the chances of chronic pain developing.
3) **Sympathetic care:** The chances of a full and quick recovery will be greatly increased by providing the cow with an environment in which she can rest comfortably, eat easily without having to compete for food and where she does not have to walk long distances [especially over rough or difficult walking surfaces]. Again the quicker and more complete the recovery the greater the likelihood of avoiding long-term complications and chronic pain.
4) **Analgesia:** Using drugs to interrupt or modulate the pain experienced by cattle will promote recovery, reduce the risk of prolonged suffering and limit production losses.

Effective pain management requires an integration of these approaches and should not rely on one single element;

for example administration of analgesics without effective treatment. There is research evidence that lame cattle benefit significantly from the receiving the aspirin-like Non-Steroidal Anti-Inflammatory Drug (NSAID) ketoprofen when it is given in association with effective lesion treatment (Whay et al. 2005) and that these combined approaches can also promote recovery of milk yield (O'Callaghan-Lowe, 2004). However, as Flower and co-workers (Flower, 2008) demonstrated in Canada, when a NSAID is given without associated treatment of the cause of lameness an improvement in gait is detected but to a very minor degree, reinforcing the message that a multilateral approach to pain management is required.

In the example of mastitis in dairy cattle, there seems to be a consensus of opinion that severe cases of mastitis cause 'significant' pain and distress to the affected animals (Hewson et al. 2007). However moderate to mild cases of mastitis still present challenges in terms of early recognition of the disease and recognition that there is associated pain. Signs of pain associated with mastitis in cattle such as altered stance, and higher heart rates, respiratory rates and rectal temperatures (Fitzpatrick et al. 2000) may also be indicators of the disease process itself, making clear cut recognition of pain difficult. In addition, the use of NSAID's for the treatment of severe endotoxic mastitis is normal practice, as the anti-endotoxic effects of NSAID's are well documented. However, this practice has perhaps deflected attention from the value of NSAID's in providing analgesia for cows with mastitis. Furthermore, veterinary practitioners are not always directly involved in the treatment of moderate and mild cases of clinical mastitis. There is however increasing evidence that NSAID's do provide pain relieving benefits in cases of moderate severity mastitis (for example see Milne et al. 2004).

The influence of human attitudes towards cattle pain

How individuals, veterinary surgeons, farmers and herdspeople respond to pain in the cattle under their care is likely to be influenced by a number of factors. These include their beliefs about whether or not cattle feel pain, their own personal attitudes to and experiences of pain and what they believe they or others around them can do to manage it. In a survey of UK veterinary surgeons, Huxley & Whay (2006) found that cattle practitioners varied considerably in their estimates of the levels of pain associated with a range of conditions and procedures. As has been previously reported, in most cases women rated pain higher than men. However, most importantly and regardless of gender, a practitioner's perception of pain severity influenced their likelihood of giving analgesics; those that perceived pain to be more severe were more likely to give pain relief in more cases. In addition, 65% of practitioners surveyed reported a belief that farmers would not be willing to pay for analgesics as a barrier to their use. Interestingly, in a corresponding survey of farmers 53% agreed with the statement "Veterinary surgeons do not discuss controlling pain in cattle with farmers enough" (Huxley and Whay, 2007). While this is clearly not an open mandate for veterinary surgeons to prescribe analgesics for cattle it does suggest that they should not assume

that all farmers will be unwilling to pay for them.

Concluding remarks

The challenge of pain is that for all individuals it is a private experience. Humans overcome this by using language as well as behavior to convey how they feel and the extent of their suffering. Animals do not have the facility of describing their pain to us which means that, although they cannot be accused of exaggerating, we sometimes take this as leave to assume that they are not hurting. As yet no definitive answer can be given as to whether animals feel pain in a manner and intensity comparable to humans, however, the weight of evidence suggests that they do suffer and that they also benefit greatly from receiving the best treatment that we can offer them.

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Reducing lameness in dairy cows: Working with farmers to manage lameness

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Introduction

The balance of responsibility for farm animal health and welfare is weighted heavily towards the farmers and farm staff who have day to day and managerial responsibility for their livestock. However, other stakeholders have an interest in or influence on the decisions that farmers make. In the dairy sector companies that buy, process and sell milk are often vigorous in setting standards for farmers to meet. Similarly, government bodies are focussed on the enforcement of legislation and ensuring compliance with regulations and minimum standards. However, many other "influencers" within the agricultural industry are positioned to work with farmers to support the development of management change and consequently welfare improvement. Groups such as veterinarians, veterinary practitioners, farm consultants, paraprofessionals (such as cattle claw trimmers, scanners and inseminators) and some charities have this remit. Much of the support they offer is in the form of advising famers to implement change as a result of professional experience and information filtering through from researchers.

Using the example of lameness in dairy cattle, there is little evidence to date that enforcement and standard setting or advisory approaches are having a substantial impact on reducing lameness in the UK national herd. In 1996 Clarkson et al. (1996) reported a mean lameness prevalence of 20.5% (25% in winter only) across a sample of UK farms; 7 years later Whay et al. (2003) reported a winter lameness prevalence of 22.1% from a sample of 53 UK dairy farms, and 7 years after that study Barker et al. (2010) found a lameness prevalence of 36.8% observed during winter visits to a sample of 205 UK dairy farms.

Of the policy instruments available to government (Webster et al., 2006), incentive schemes such as the successful initiative for broiler footpad health described by Algers and Berg (2001) are currently not being used in relation to UK dairy cattle lameness. Farm Assurance assessments are much more widespread but implementation of their standards does not necessarily guarantee high levels of animal welfare (Main et al., 2003). There is mixed evidence regarding the success of advisory approaches in bringing about dairy cattle welfare improvement. Green et al. (2007) reported achieving a 22% reduction in the proportion of cows with clinical mastitis following a health planning intervention, while in contrast Bell et al. (2009) reported that an intervention to reduce lameness in dairy heifers was largely ineffective as farmers did not implement planned actions. The concept of "giving advice" is likely to be understood and practiced very differently by people in advisory roles. Jansen (2010)

studied 17 veterinarians – farmer conversations during herd health visits on Dutch dairy farms. The veterinarians' communication skills were evaluated and their conversations were found to lack structure, active listening and efforts to elicit farmers' opinions and values. Often in formalised veterinary advisory visits the veterinarian has a set of tools to support the consultation, for example a pro-forma for a health plan, a disease cost calculation tool or a structure for formulating an action plan. However, it appears that the communication skills and strategies that underpin the use of such tools are vitally important for leading farmers towards implementing change and compliance with action plans.

The process of introducing changes to management practices, strategies and routine behaviours is difficult. Most individuals find introducing changes, particularly health related behaviours, to their own lives difficult. This is evidenced by the discrepancies between knowledge of positive health behaviours and actual levels of implementation. For example the Food Standards Agency (2004) reported that despite a substantial increase in people's awareness of the health benefits of eating fruit and vegetables only a two percent increase in people achieving the target of eating five portions of fruit and vegetables per day was seen between 2000 and 2003. This discrepancy between knowledge of action that should be taken and the actual implementation of change is a well recognised phenomenon (McKenzie-Mohr and Smith, 1999) and presents many challenges when trying to work with farmers to implement research findings on farm to bring about welfare improvement (Whay, 2007).

Example: Intervention study to Reduce Lameness in Dairy Cattle

In the UK the need to encourage farmer uptake of lameness-related advice led to a relatively large scale intervention project called the Healthy Feet Project. The project was supported by Tubney Charitable Trust and the initial partners were Milk Link, Long Clawson, OMSCO, Freedom Food and Soil Association Certification. The project also went on to work with an even greater number of industry stakeholders to insure wider application of the findings from the project. The project team developed a range of tools to promote on-farm implementation of lameness prevention activities using the principles outlined below. For each principle the project team developed specific methodologies applicable to UK dairy farms. An intervention study involving 140 intervention and 87 control farms was then initiated to examine the effect of this approach. Dairy farms were recruited via direct contact or via the relevant milk companies. A team of four researchers with a good understanding of lameness then undertook a four year programme of visits, follow up telephone contact and group meetings on those farms receiving the intervention.

Intervention approaches

The primary focus for the project was to promote the uptake of actions / activities likely to reduce lameness or to refine existing lameness reducing activities to increase their effectiveness. These actions were based on existing knowledge of risk factors known to influence lameness and on advocating the early treatment of lame cows. Although mobility

scoring and formal risk analysis are valuable tools for promoting lameness improvement, it was considered critical that these management tools did not become the primary focus of the initiative. It is clear that when management tools are introduced without consideration of the target audience some resistance is inevitable. This has been seen with health planning initiatives which have been variably received by UK farmers (Bell and others 2006). So the project did not concentrate on insisting that farmers agree with the results of a lameness assessment which was considered confrontational. It was thought more important to provide an identification list of cows that were likely to benefit from treatment rather than present an overall prevalence figure. Similarly for the risk assessment process, even though formal evaluation tools were available, the dialogue with producers did not concentrate on explaining risk assessment process or detailed finding on farms. The risk assessment web site (www.cattle-lameness.org.uk) was, therefore, only advocated for use by those farmers and their vets/advisors with a particular interest.

Since the primary focus was on promoting an uptake of lameness relevant activities, the project team developed a social marketing approach suitable for UK dairy farmers. Social marketing (McKenzie-Mohr & W Smith 1999) involves the application of marketing principles to an area of social benefit, in this case animal welfare. Farmers in the UK often work alone on their farms, they have very limited contact with others and their days involve completing a lot of repetitive, routine tasks. So social marketing for farmers needed to include more contact with individuals than would normally be expected, this contact was delivered through the four researches visiting each farm at least once a year.

The key elements of the social marketing "type" approach used in the project are outlined below:

a) Recognizing the Benefits and Barriers to Change

Farmers are more likely to take action if they perceive **benefits**, although, this change may be limited by any perceived **barriers**. For every desired change in behaviour there will be both perceived benefits and perceived barriers. A potential benefit may include believing that the change will save time, offer economic benefit, or perhaps contribute to making other tasks on the farm easier. For example, keeping the feet of cows clean in order to reduce infectious lameness may also result in cleaner udders and faster milking times. A potential barrier to achieving cleaner feet might include a lack of appropriate equipment, for example the yard scraper may be inefficient and need repair, modification or replacement or a perceived lack of time to increase the frequency or diligence of yard scraping.

It was important that the project team who were promoting behaviour changes understood the details of the possible benefits and barriers as perceived by the farmers. It was also essential that the project team members encouraged implementation of changes on farm by using phrases and quotes that made sense to the farmers they

were speaking to. This was achieved by inviting farmers to a series of focus groups where their ideas and the language they used was listened to very carefully.

b) Facilitating farmers to plan their own changes

Farmers are more likely to implement management or routine that result from their own ideas i.e. a "farmer-owned approach". A good facilitator will not provide unsolicited advice, i.e. **they will not tell the farmer what to do**. The goal should be helping the farmer to generate solutions that are appropriate to his or her own farm. Members of the project acted as facilitators and walked around the farm with the farmer asking questions about particular aspects of the farm which were likely to be risk factors for lameness. During this walk round the farm the facilitator addressed barriers to change presented by the farmer by encouraging him or her to weigh them against potential benefits. The facilitator also shared the experiences of other farmers by describing actions they had taken, and offered contact details of other farmers (with their permission) that had found ways of tackling a similar problem. At the end of the facilitated visit, before leaving the farm, the facilitator compiled a summary of the changes the farmer had identified as being possible to make into an action list including notes on who would be responsible for implementing each change (the farm manager, herdsman, tractor driver etc) and when the change was going to be implemented along with a space to tick when the change had been introduced. This list was then left with the farmer for the coming year.

c) Establishing lameness prevention activities as a normal behaviour or "Norm"

Farmers are more likely to change behaviour if they know others have done the same. Establishing"norms" is the process for reassuring farmers that others are also making changes i.e. that it is normal behaviour to make changes to reduce lameness. The project brand "Healthy Feet Project" and its use in all communications ensured that all the participants are aware they belong to a larger project in which others are involved and that they had a group identity they could be proud of. Norms were also created through describing what changes other farmers had made on their farms. This helped to address perceived barriers but also acted to reassure each farmer that others were also making changes and overcoming problems. The activities of other farmers were relayed using verbal descriptions, photographs of what they had changed (with their permission) and a regular newsletter which featured case examples of farms where changes had been implemented.

d) Encouraging Commitment to the project

Commitment is the key for sustaining behaviour change. There are various techniques to encourage more positive commitment. Within the lameness project all participating farmers were given a jacket lapel badge and a car sticker of the project logo and they were encouraged to display them. Although this is a relatively small act, by showing others that they were part of the project they were more likely to go on to implement the more challenging changes. Further areas

where commitment was promoted was through asking farmers to put their signature on the action plan which is drawn up during the facilitation visit and through asking their permission to show others photographs of their farms (with their names clearly identified on them)

e) Providing Prompts as reminders to implement new activities

Prompts act to remind people of agreed activities and help sustain the new behaviour. Although peoples' intentions to change a particular practice or habit are generally good, new activities can easily be forgotten or slip from mind, especially when they involve making changes to existing routines or when people find themselves under time pressure. Within the project a catalogue of suppliers of equipment, services and materials that were commonly needed when making lameness reducing changes was presented to the farmer at the time when the facilitated action list was generated. The catalogue was intended to prompt picking up the telephone and placing an order or booking a service etc. as a common stalling point for action was farmers saying they didn't know where to buy a material, for example wood shavings to spread on cows beds to increase their lying comfort; the catalogue overcame this.

Selected Results

Of the 227 farms which joined the start of the study 189 remained in the study throughout the 3 years. Lameness prevalence was lower in both the Intervention (also called Monitored and Supported) Group (n=117) and the Control (also called the Monitored Only) Group (n=72) at the end of the 3 years when compared to the mean prevalence for each group recorded at the initial baseline visit at the start of the project. In the Intervention Group the initial lameness prevalence was 33.3% ± 1.76 SEM versus a final prevalence of 21.4% ± 1.28 SEM. In the Control Group the initial prevalence was 38.9% ± 2.06 SEM versus final prevalence was 27.0% ± 1.94 SEM (Main et al. 2012).In the Intervention Group the types of risk factors for lameness that were identified and addressed fell into six broad categories: reducing standing and increasing lying time, improving the underfoot surfaces, implementing or improving footbathing, improving hygiene around the cows feet, implementing early and effective treatment of lameness, and "other" which incorporated a wide range of potential actions from building a new parlour to reducing herd size. Fig. 1 depicts the total number of action points listed in each of the target areas described above, and the number of action points that went on to be implemented on the farm. Improving underfoot surfaces was by far the most common category of action point identified (n=257) and was also the area with the greatest number of implemented action points (n=123). In contrast, improving foot hygiene was the area with the least number of target action points (n=26) and consequently was the area with the fewest implemented action points (n=11).

Changes were not only implemeted on the Intervention Group farms; the ControlGroup farms also implemented neumerous changes to management which may have had an impact on

lameness levels. Across all farms the majority of changes were judged by researchers reviewing the farms to be likely to positively benefit lameness management. Table 1 illustrates the numbers and percentage of changes judged likely to be positive in managing lameness; likely to be harmful, i.e. increasing the risk of lameness; and those changes that were equivocal or the consquences of which were unclear. Overall the Intervention Group made a greater percentage of changes likely to benefit lameness and a lower percentage likely to increase the risk of lameness than the Control Group group.

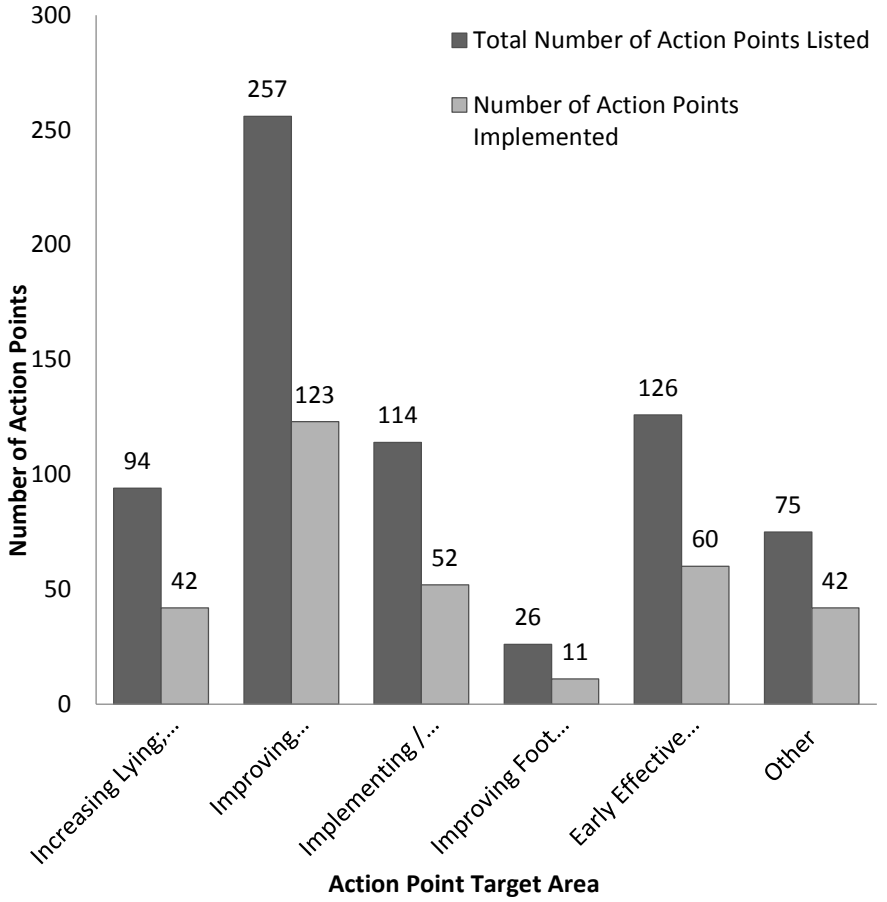

Figure 1
The total number of lameness reduction action points listed identified by vets and farmers, and the total number that were implemented (reproduced from Whay et al 2012).

	Number (%) of changes implement likely to positively benefit lameness management	Number (%) of changes implement likely to increase the risk of lameness	Number (%) of changes implement likely to have a minimal effect on lameness (either positive or negative)	Number (%) of changes implement with unknown effect on lameness
Intervention Farms	757 (78.7%)	82 (8.5%)	65 (6.8%)	58 (6.0%)
Control Farms	329 (70.6%)	77 (16.5%)	27 (5.8%)	33 (7.1%)

Table 1: The likely impacts on lameness of changes implemented on both intervention and control farms, as judged by reserachers visiting the farms.

Discussion

This study demonstrated that it is possible for farmers to reduce lameness, although notably there was a limit to the amount by which lameness was reduced in both the intervention and control groups. It was noticeable that more potential intervention targets were identified than implemented by farmers. The reason why some types or intervention activity is more readily implemented by farmers is worthy of further investigation as it is currently unclear. Traditional explanations, such as lack of willingness to invest, were not supported by our data which showed that some farmers invested considerable sums of money in their interventions.

The terms 'Intervention Group' and 'Control Group' are somewhat misleading as the control group received repeated visits and lameness prevalence feedback during the course of the study and consequently also received some level of intervention effort (Whay 2007). It was noticeable that the more intensive intervention activity encouraged a higher implementation of management changes and fewer of the changes implemented were likely to be detrimental to lameness control.

A key principle behind this project was to work with farmers and to encourage them to manage their own lameness problems. The project recognised that farmers have a great deal of expertise about their own farms and the health problems they have to manage and looked to work positively with this expertise rather than imposing external advice.

Acknowledgements

Implementation of the project described in this paper involved invaluable contributions from Katherine Leach, Zoe Barker, Anouska Bell, Clare Maggs and Nick Bell

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Limb health in rural conditions

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Lameness is one of the most important factors in cow health. Milk loss, fertility reduction and early culling are the most important outcomes of lameness. In rural area with improving breeding techniques and affinity of the owners to high producing cows, the importance of lameness was increased and needs more scientific works.
In current field study 2200 cows aged between 6 month to 13 years old were included. Data of age, breed, pregnancy, ratio, volume of concentrate, hoof trimmings were recorded in each cow. The above mentioned cows were kept in 400 rural farms in Lorestan province. Locomotion status of the cows (Back posture and leg scoring were evaluated.
Sixty percent of the cows over 5 parity had leg score 2 (deviation between 17-24) and were classified as moderately lame cows. Forty percent of the cows with parities between 2-5 were not normal and in the last group (cows between 6 month to two years) hoof deformities specially in the age less than 12 month were recorded.
Breeding techniques and changes of owners idea were affected on lameness status and may provide high financial loss. Lack of knowledge, lack of education and belief in this part can be corrected by intensive programs**.**

Study on annual and seasonal lameness prevalence in dairy cattle herds of kermanshah province: the first comprehensive study

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Lameness is one of the most important causes of economic loses in dairy cattle industry around the world. Therefor having information about the incidence, prevalence and causes of lameness in each area is necessary to design therapeutic, controlling and preventive measures. Kermanshah province; in west of Iran, has a considerable numbers of industrial dairy farms with about 10000 Holstein cow population. There was no any comprehensive study which had been done on lameness prevalence in Kermanshah dairies; though, this study was planned to evaluate lameness prevalence in industrial diary cattle herds in this province. This survey was performed in one-year duration (4 seasons) during years 2014 -2015 in 12 herds with various population. Regarding the herds sizes they were divided into 4 groups (small herds, n:5, medium herds, n:3, relatively large herds, n:2 and large herds n:2). Locomotion scoring (LS) was done based on 5 point Sprecher method in each 4 separate seasons. Cows with LS 3-5 were considered having lameness. Total of the 12605 cows have been scored in all seasons and the average annual lameness prevalence was calculated as 37.4%. The total number

of cows that have been scored and seasonal lameness prevalence in spring, summer, autumn and winter, were 3170 cows (35.3% lame), 3179 cows (36% lame), 3051 cows (37.7% lame) and 3105 cows (40.6% lame) respectively. Average annual lameness prevalence in 4 groups of herds was 35.6% in small herds, 40.6% in medium herds, 43.4% in relatively large herds and 32.5% in large herds. There are large variations in present reports about the rate of lameness prevalence in different countries and herds around the world; so It has been reported from 5% to more than 50%. These variations may be due to several factors such as; housing system, herd management system, herd size, climate, season, breed, nutrition, amount of milk production, quantity and quality of hoof care programs, and etc. With regard to direct and indirect large economic loses due to lameness in dairy cattle herds, it is necessary that farmers, Managers, veterinarians and other related persons to take more attention to this problem.

Key Words: Kermanshah province, dairy cow, Lameness prevalence

Solar horn hardness in different digital zones of the cows

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Lameness is a crucial welfare issue in modern dairy husbandry that could result in serious economic losses to dairy producers because of decreased milk yield, reduced fertility, and increased treatment costs and culling rates. Quality of the cow's claws, especially their hardness, may influence the likelihood that the cow will suffer from claw lesions. Although various factors (i.e., nutrition, genetics, etc.) affect claw quality, the environment in which the cow is housed is very important. Resistance of claw horn to environmental effects likely depends on its hardness because hardness influences rate of horn wear and erosion. Some researchers claim that this relationship puts cows with wet claws at a higher risk of developing claw problems because the horn resistance is diminished.

This current study was done in a dairy herd with total of 5800 dairy cows and 2780 milking cows. The average annual daily milk production of the farm recorded as 36 lit/day, cows milked three times a day and housed in free stall barns. Hoof care program were done on the following basis: monthly locomotion scoring, hoof bathing (3-4 days a week), regular hoof trimming at least two times a year by a professional veterinarian hoof trimmer, data recording and analysis.

Two groups of cows were selected. Group one on days in milk 120 and group two before drying were referred to trimming chute. Hardness recorded by shore D durometer. Data analyzed in each group and between the groups using two way ANOVA and p values under 0.05 consider significant. Hardness of the solar area in zones one and five (area of toe ulcers and necrosis), four (area of sole ulcer) and three (area of white line disease) were measured. The hardest area (mean ± SD) of the hoof in group one was located in zone 5 (37.11 ± 6.18) that

was significantly harder than area 2-4. And the hardest area in group two was located in zone 5 (49.43 ± 4.94) that didn't show any significant difference with the other area of the sole. All area of the hooves were significantly harder in group II than group I ($P<0.05$).
Days in milk plays an important role in hoof hardness that may be the reason for more claw horn lesions in 100 days after parturition. This may be a result of negative energy balance, peak production, less comfort, loosing body condition score and so many other problems that may originate in transition period.

Evaluation of the culling rate in cows with interdigital necrobacillosis

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Culling in cows is a complicated condition. Many factors such as, age (parity), milk production, fertility, health, season, feed price, and other variables may influence severity of this condition. Infectious foot diseases are common in dairy herds, causing welfare reduction and financial losses. Interdigital Necrobacillosis (INB) which is a painful condition is one of the most important infectious causes of lameness. Fusobacterium necrophorum has been isolated from over 90% of clinical cases of INB in cattle. When the organism enters subcutaneous tissue through interdigital skin after traumatic damage or the action of irritant agents in slurry this condition may happen. Lack of micronutrients, genetics and disturbances in the local immune system are known as predisposing factors.The overall incidence of INB is probably less than 5%, but in epidemic outbreaks the incidence of the disease can be as high as 20% of the milking cows in a herd.
This current study was done in a dairy herd with 910 productive cows (including milking and dry cows), during 12 month period started from March 2014 till February 2015. All cows housed in free stall barns and milk three times a day. The average production of the cows during this period recorded as 36.5 lit/day. Hoof care programs including regular hoof trimming by veterinary practitioners and skilled hoof trimmers was done as the cows at least trimmed two times a year and total 4 times including different inspections and treatments referred to hoof trimming chute. Days in milk (DIM), milk production, parity recorded in all cows in addition to the records of the diseases. The INB located in zone 0 of the hooves selected as treatment group and in addition to the above mentioned records culling rate in these animals in comparison to the control (the cows without any digital disorder 6 month before to 6 month after case occurrence) were recorded. In treatment group total of 94 (annual incidence of 10.32%) cases recorded and 40.42% of them were culled in average of 8.97 days after detection. This number were significantly higher than culling rate of the control group (23.3%)(Chi square test, $P=0.009$). No significant difference between culling rate of the cows with lower production

(less than 30 Lit/day) and higher production (more than 30 lit/day) recorded (P>0.05). Thirteen cows were culled in treatment group (32.5%) with days in milk less than 150 days that did not show any significant difference with the culling rate in this group with days in milk over 150 days (49%)(P>0.05).

It seems that despite of a very intensive care of the affected animals still culling rate in INB animals is higher than normal cows that need special attention to control the hygiene and other predisposing factors. Days in milk and milk production record of the cows do not affect the culling rate following INB.

Sole ulcer occurrence cure rate in a dairy herd

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This 12 month current study were done in a dairy herd consisting of 1340 productive cows (Milking and dry cows) started March 2013- February 2014. Cows housed in loose stalls, milk three times a day. And receive total mixed ratio. The average milk production of the cows during this period recorded as 39.2 lit/day. Hoof care programs including regular hoof trimming by skilled hoof trimmers was done as the cows at least trimmed two times a year and total of 3.45 times including different inspections and treatments referred to hoof trimming chute during the year. Data of days in milk (DIM), milk production and parity recorded in all cows in addition to the records of the digital disorders. Data recorded on a zonal basis (1-12) of the digits and any wounds in zone 4 recorded as sole ulcer and included in this current study. All wounded cows inspected on a 15 days basis and covering of the lesion with a film of horny tissue considered as cured wound. New cases selected based on new lesions at least 3 month after curing of the previous lesion or occurrence in another digit or zone.

Total of 57 sole ulcers were detected. Most ulcers occurred in hind feet (51, 89.47%) and just 6 ulcers (10.52%) occurred in forelimbs. Twenty three ulcers in right hindlimb (40.35) and twenty ulcer occurred in left hindlimb (35.08%). In twelve cows (21%) sole ulcer detected in two digits. Sole ulcers (mean ± SEM) cured in 82.66 ± 7.95 days, started from 15 days to 364 days after its occurrence.

Although the ulcers cured longer when the cow affected in DIM less than 100 (87.65 ± 8.15) than higher DIM (82.66 ± 7.95) but the difference was not significant (P>0.05). Cows with milk production less than 30 lit /day and higher production didn't show significant changes in duration of treatment (P>0.05). Although cows with low body condition scores (less than 3.2) were treated faster (82.66 ± 7.95) than cows with higher body condition scores (more than 3.2, 92.35 ± 8.48) but the difference were not significant (P>0.05).

Days in mil, milk production and BCS at the time of sole ulcer occurrence does not affect duration of treatment.

Evaluation of mastitis as a cause of lameness and digital lesions in dairy cows

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Lameness and mastitis beside infertility are major health concern and economic loss in dairy herds that affect animal health and reduce productivity and comfort of the cows.
Regards to occurrence of lameness after infectious and endotoxemic conditions and back to causative agents in mastitis and scattered reports, the main objective of this current study was establishing possible correlation between lameness and infectious conditions like mastitis.
This current study was done in a large dairy herd during a 9 month period. Cows were housed in loose housing system and fed by total mixed ratio. Mastitis recorded as a three point scale that in score one, milk clots in fore milking considered as the most important finding, in score two in addition to milk clots general conditions of inflammation was obvious in the udder but no general sings recorded and in score three in addition to the above findings cows express general illness including fever, anorexia. Hoof care and lameness management were done in the herd and in addition to hoof trimming by professional hoof trimmers and veterinary practitioner, hoof bathing, bedding management, heat stress control were done and data recorded.
Five hundred forty six cows affected with different mastitis scores were selected during 9 month started March 2014 - January 2015. Hoof lesions recorded up to three month after mastitis occurrence. The same number of cows selected randomly from negative mastitis cows as control group and all lameness data recorded in this group as well. Lameness compared between two groups and $P<0.05$ considered as significant. Locomotion scores of the cows also recorded based on a five point scale monthly and compared from three month before mastitis till three month after mastitis.
Results showed that overall lameness were not different between groups ($P>0.05$). New cases of noninfectious lameness were significantly higher in mastitis than control group ($P<0.05$).
Sole ulcer, White line disease, toe ulcers were higher in mastitis group but didn't show significant difference with control group. In contrast digital dermatitis were significantly lower in mastitis group ($P<0.05$).
It seems that mastitis can play a role in increasing incidence of noninfectious lameness. However since some causative factors in both conditions maybe the same, lameness and mastitis may be a result of a same causative agent that needs further study. Lower rate of digital dermatitis in mastitis group maybe a result of antibiotic treatment.

Incidence of hoof lesions in dairy farms in Iran

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Lameness have known as the most important problem in dairy cattle welfare and economic losses and got the third place after infertility and mastitis. Different incidence of lameness has been reported base to different production, climatic, management conditions. Knowing the overall incidence of different lesions that resulted in lameness can play and important role in understanding current situation and making targets for control and management of the conditions.

This current study was done to detect the incidence of hood lesions in Iran. Four industrial dairy herds were selected in different parts of Iran. With 933 to 4490 productive cows (milking and dry) cows, in different climates from very cold to hot and low to high humid weather. Cows were milked three times a day and received total mix ratio. Cows were housed in loose stall to free stall barns. Hoof care program (by a veterinarian) started at least 5 years before start of the study. Hoof trimming was done on the following basis; each cow was trimmed two times a year as one time is immediately before drying and the other is around 100 days after parturition. In addition to normal hoof trimmings cattle with locomotion scores 4 and 5 on a five point scale, repeat breeders and referral cows also referred to trimming for detection of any possible lesion in the hoof.

Data were recorded in a hoof trimming record sheet, and finalize in excel sheet and management software of the farms. Injuries recorded by its affected zones (1-12). Sole Ulcer (SU), toe ulcer (TU), white Line disease (WLD), digital dermatitis (DD) and interdigital necrobacillosis (INB) were notified in this current study. Information recorded from March 2012 to February 2014 (two years). The annual incidence of each lesion and overall incidence of the lesions were reported.

Total of 20000 cows were evaluated with 132000 times of inspection in this period. The overall incidence of the lesions was different between farms (14.34 – 61.89%). The most prevalent lesion was sole ulcer among non infectious causes and digital dermatitis among infectious causes. The most prevalent lesion was digital dermatitis in three out of four farms. The overall annual incidence of lesions recorded as 31.75%. The annual incidence of each lesion in Iran recorded as 9.70% for SU, 1.53% for TU, 5.75% for WLD, 11.66% for DD and 3.00% for INB.

Toe ulcer incidence and cure rate in a dairy herd

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Lameness is a multifactorial condition. Primary causes include infectious agents (e.g., foot rot), laminitis, conformational or other lesions (e.g., corkscrew claw, leg injury); and claw lesions such as white line disease, thin sole-induced toe ulcers, sole ulcers, heel ulcers, toe ulcers, sole punctures, and thin soles. Compression of the corium between the sole and third

phalange can result from over trimming or inflammation and rotation of the phalange due to laminitis. This compression can cause the formation of ulcers in the apical region of the sole. These lesions are typically found in the apical portion of the sole adjacent to the abaxial white line in zones 1 and 5 of the sole.

This current study was done in a dairy herd with 890 productive cows (including milking and dry cows). The study was done during 32 month period started from June 2013 till January 2016. All cows housed in free stall barns and milk three times a day. The average production of the cows during this period recorded as 39.3 lit/day. Hoof care programs including regular hoof trimming by veterinary practitioners and skilled hoof trimmers was done as the cows at least trimmed two times a year and total 4 times including different inspections and treatments referred to hoof trimming chute. Data of days in milk, milk production, parity recorded in all cows in addition to the records of the diseases. The toe ulcer (TU) located in zones 5 and 1 of the hooves selected. Total of 91 cases of TU were recorded with an annual incidence of 6.74%. The average milk production in the affected cows recorded as 32.95 ± 10.82 that were not different from the average production of the herd during the same period. Cows affected with this condition (mean ± SEM) were in days in milk 216.77 ± 17 that varied from 9-666 days. The average healing time in treated cows recorded as 90.3 ± 7.56 that varied from 14-503 days and 1.94 ± 0.12 blocks were used for treatment. The average cure rate in cows with days in milk (DIM) less than 100, between 100-200 and more than 200 days recorded as 102.54 ± 21.26, 80.85 ± 9.41 and 89.52 ± 9.83 respectively. Occurrence of the toe ulcer in different days in milk did not affect its cure rate significantly ($P>0.05$).

Using metabolic profile test as a predictor of lameness indices and hoof lesions in dairy cows

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Lameness is the third most important factor affecting economic losses after mastitis and infertility in dairy herds. Lameness plays an important role in increasing culling rate, mastitis and decreasing reproduction performance. One of the most important factors, causing non-infectious lameness, are metabolic disorders, which are more important around parturition and peak of lactation. Some of these disorders can be assessed through metabolic profile test (MPT). MPT by measuring energy, protein, and mineral indices, aids in diagnosis and prediction of such disorders.

In this study ability of MPT findings in predicting lameness and non-infectious wounds in hooves were evaluated. The study took place in a dairy farm with 4200 milking cows and MPT was performed 8 times through 2 years.

Five groups of cows were selected for sampling: fresh cows in second parity and higher, fresh heifers, high producers, moderate producers, and close-up cows. The following metabolites were measured in Sera of

cows: glucose, blood urea nitrogen (BUN), cholesterol, total protein, albumin, globulin, calcium, phosphorus, magnesium, sodium, potassium, AST, beta-hydroxy butyric acid (BHBA), and non-esterified fatty acids (NEFA). Hoof trimming records were used in this study. Hoof trimming were done on the following basis: Cows in 100 – 120 days in milk, repeat breeders, high locomotion scored cows, dry cows and referred cows due to lameness. All new lameness and diseases occurrence were recorded. Sole ulcers in zone 4 and white line disease in zone 3, were evaluated from 3 month before to 3 month after MPT. All data were analyzed by ANCOVA in SAS software.

Results showed that serum albumin and protein reduced significantly before occurrence of sole ulcer and hemorrhages in sole. AST significantly increased in cows with hemorrhage and sole ulcer. NEFA increased significantly before occurrence of hemorrhage and / or sole ulcer. High-scored and referred cows due to lameness had negative correlation with serum cholesterol concentrations. Cows with sole ulcer and hemorrhages showed higher level of calcium before injury ($P<0.05$).

Although, there are some significant relationships between hoof disorders and serum biochemistry, but it remains to be elucidated whether MPT can play a major role as a predictor tool in these conditions. More studies need to be done to draw a practical conclusion. The present experiment as a preliminary study indicated that MPT has potential to act such a role.

Longitudinal observation of hoof lesions causing lameness at herd level

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Lameness in all animals known as infirmity or abnormality in both normal and natural walk and always describes as one of the most important problems in dairy cow herds that infectious and non-infectious agents brings about it, therefore lameness in dairy cow describes as a multifactorial disease. Appearance of epidemic lameness takes third place in order of prevalence after mastitis and reproductive disease in dairy cow herds. It can import many economical failures on animal husbandry society such as reducing of milk yield, progressive body weight loss, infertility and eventually early cull of lame cows. This observation was carried out at a dairy herd in the vicinity of Tehran during the two years period in a total of 830 cows. In each observation all of the lame cows were assessed using Spreecher 1-5 scoring lameness after the hoof inspection at the trimming box. Results of this study showed that from 171 lame cow, 50 cases had digital dermatitis, 34 cases had white line issues, 9 cases had heel disorders, 47 cases had sole injuries, 31 cases had toe problems, 2 cases were observed with double sole and one case of thin sole is confirmed. Suggestions were made for pain relief and wound healing for all cases. These suggestions include a wide range of treatments from application of local

bandage to installation of a wooden block on the sole of the sound digit which removes the pain during weight gain; aforementioned treatments continue until rehabilitation.

Key word: Longitudinal observation, Lame cow, Hoof lesions.

Chroumium methionin can affect comfort and feeding behaviour of growing beef steers

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Chromium (Cr) is required for insulin metabolism and, thus, for optimum essential nutrients uptake by peripheral cells. It amplifies insulin signaling and facilitates cell glucose entry. Previous researches indicate that increased dietary Cr supply can benefit post-weaning insulin and glucose and affect rectal temperature. Current experiment was conducted to determine the effects of feeding chromium methionin (Cr-Met) to growing beef steers on performance traits, blood metabolites, rectal temperature as an index of comfort and feeding behavior. Twenty-six growing Holestein dairy calves were randomly divided in two groups to fed 0 (first BW=160±12 kg) and 0.9 ppm Cr-Met supplement (first BW=148±10 kg). Two group of calves were fed and kept in two different common pens in farm close to Saveh city (central Iran). Before beginning of feeding experimental diets, calves in each pen fed with basal diet (forage to concentrate ratio of 50:50; crude protein=15% of dry matter and Metabolizable energy=2.34 Mcal/kg of dry matter) for ten days. Group dry matter intake during six days and body weight of each calf at the end of this period was measured and used as covariate in final statistical model. After the commencement of experiment, for calves in Cr-Met group one gram of Availa Cr added per kg of DM of basal diet which finally resulted to 0.9 ppm of supplement Cr-Met. This study performed in two different periods of 28 days with 21 days' adaptation to diets and later 7 days for sample collection within each period. Calves fed with basal diets without adding Cr-Met for two weeks between two experimental periods. Data was analyzed with proc mixed SAS and least significant difference (LSD) test used to compare means. Results showed that final weight, dry matter intake and feed efficiency were not affected by Cr-Met supplement ($P>0.05$). Eating, rumination and resting times were similar between two groups of growing steers ($P>0.05$). Steers fed with Cr-Met had lower rectal temperature (38.74 versus 39.62, SEM=0.139; $P=0.0004$) and tended to have lower standing time (346.2 vs. 399.5 min, SEM=13.2; $P=0.09$). Blood glucose, insulin, insulin to glucose ratio, total protein and urea were similar between two groups ($P>0.05$). The average of temperature humidity index (THI) during this study was 64.3 (SD=7.7) indicating no thermal stress. It is well documented that increased rectal temperature indicates an abnormal health status. Higher rectal temperature in calves fed with no Cr-Met supplementation diet still was in normal range for steer. In cattle more standing behavior indicates lower

comfort. In this study no illness signs were observed. These data indicate that Cr-Met affects body core temperature and standing behavior although blood metabolites and performance traits did not change. Cr-Met have been shown to decrease rectal temperature in several studies. Data on the effects of Cr-Met on animal behavior is rare and more researches are required.

Key Words: Chromium methionin, growing steers, rectal temperature, standing behavior

Body condition score, is it a risk factor for lameness?

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Lameness is one of the most significant challenges in the dairy industry. Extensive effects of lameness on herd performance are reported includes milk loss, impaired reproductive performance and finally lameness. Locomotion Scoring system have been used to distinguish the degree of lameness. Cows categorize into 1 to 5 from normal to severely lame.

Energy reserves in the form of fat and muscle (a.k.a. body condition) are extremely important for reproduction success. Body Condition Score (BCS) range from 1 “very thin cows” to 5 “severely over conditioned cows”. Ideal condition scores fall in the range of 3 to 4 at dry off and calving and 2.5 to 3.5 at peak lactation.

This current study was done in a dairy herd with average of 4700 productive (Milking and dry) cows from March 2013- February 2014. Cows housed in free stall barns bedded with sand, milk three times a day and feed by total mixed ratio. The average annual milk production recorded as 40.47 lit/day. Body condition scoring was done on monthly basis by a 5 point scale by a single observer. BCS was done to accomplish management processes. Locomotion scoring also was done on a monthly basis on a five point scale that cows with score 1 known as sound and cows with score 5 known as severely lame cows by a single veterinarian. Locomotion scores 1-3 considered as non-lame and locomotion scores 4 and 5 consider as lame in data analysis.

Total of 49754 cows scored during 12 month (average 4146.16 ± 244.54). 6.64% scored 2 and less, 30.65% scored 2-3 and 62.69% scored more than 3 during this study.

Group 1 consist of cows with BCS 2 and less, group two consist of cows with BCS between two and three and cows with 3 and higher BCS assigned in group three. Kruskal-Wallis test showed a significant difference between lameness occurrence in different groups under study, as cows in groups one and three showed more lameness than group two ($P<0.05$). Lameness maybe a result of high body condition score and also maybe a cause for low body condition scores cows that need further investigation.

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Scientific program of the first Regional Conference on Cow Comfort and Lameness (RCCCL)

Tuesday, May 10, 2016

Time	Topic	Lecturer	Panel
8:00- 9:00	Registration	-	-
9:00- 9:45	Scientific assessment of cow comfort	Daniel M Weary	Iradj Nowrouzian
9:45- 10:30	Digital Dermatitis: New Ideas on an Old Disease	Jan Shearer	Iradj Nowrouzian
10:30-11:15	Coffee Break, Poster presentation, Commercial Exhibition	-	-
11:15- 12:00	Digital Dermatitis: Successful management	Arturo Gomez	Daniel M Weary
12:00- 12:45	Lameness and pain in dairy cows: does it hurt and does it matter?	Helen R Whay	Daniel M Weary
12:45-13:30	Feeding behavior comfort and sickness behavior	Nina Von Keyserlingk	Daniel M Weary
13:30-15:15	Lunch, Poster presentation		
15:15- 16:00	Bio – Surveillance and Biosecurity: A Promising action to stop the incidence of Digital Dermatitis in dairy Cows	Iradj Nowrouzian	Seifollah Dehghani
16:00- 17:45	Hoof care session The comparison of hoof dry content in different parities, seasons and stage of lactation Solar horn hardness in different digital zones of the cows	Amir A. Mohieddini Amin Khaghani	Seifollah Dehghani

Opening ceremony: 19:00

Scientific program of the first Regional Conference on Cow Comfort and Lameness (RCCCL)

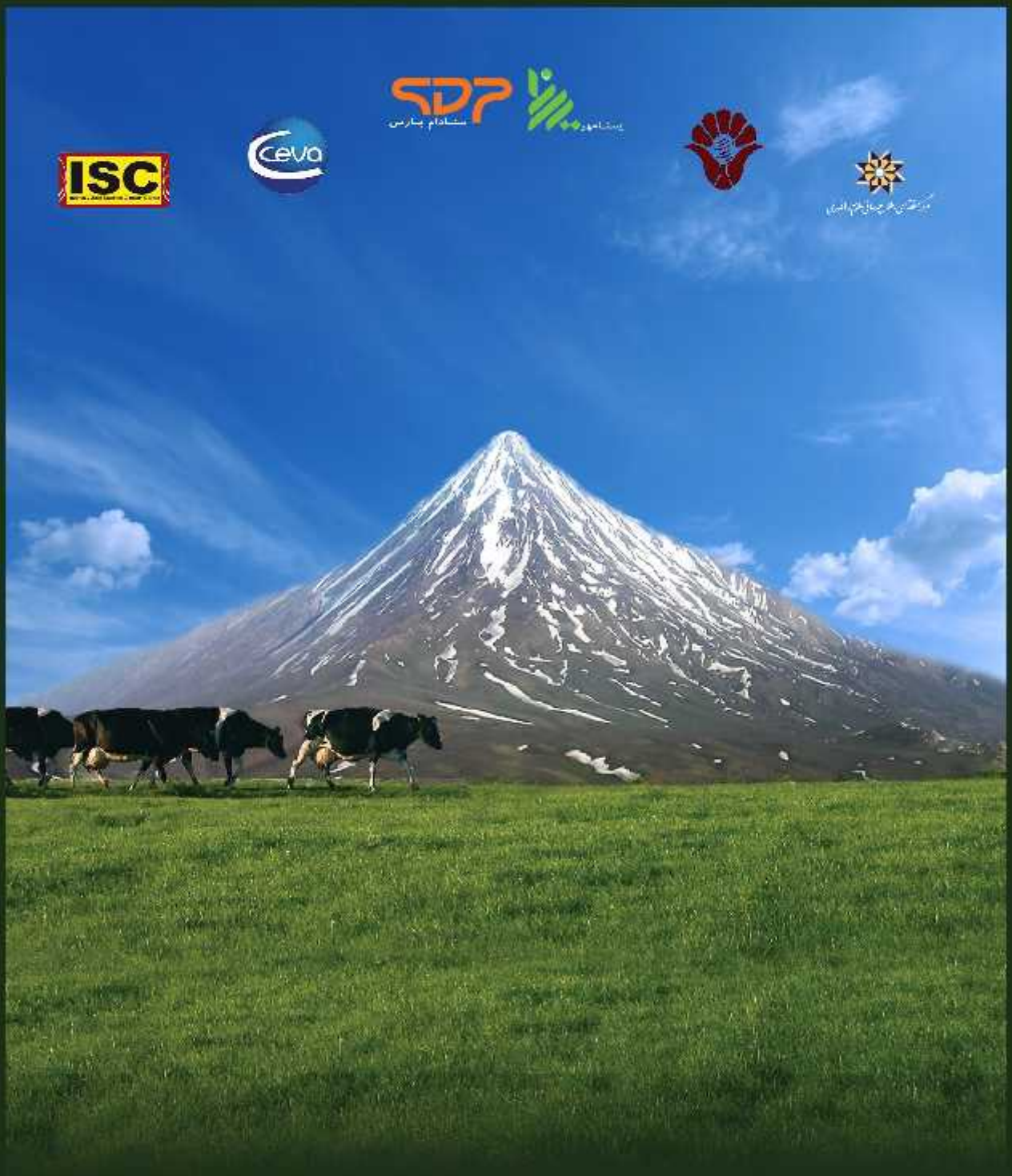
Wednesday, May 11, 2016

Time	Topic	Lecturer	Panel
9:00- 9:45	Development of Claw Horn Lesions- How do they start and where do they end up	Ricahrd Laven	Nina Von Keyserlink
9:45- 10:30	Treatment of claw lesions: Necessary or not	Jan Shearer	Nina Von Keyserlink
10:30-11:15	Coffee Break, Poster presentation, Commercial Exhibition	-	-
11:15- 12:00	Risk factors for lameness and role of benchmarking	Nina Von Keyserlingk	Arya Badiei
12:00- 12:45	Pain: Lameness and common management procedures	Dan Weary	Arya Badiei
12:45-13:30	Cattle lameness monitoring, use of locomotion scoring	Ahmadreza Mohamadnia	Arya Badiei
13:30-15:15	Lunch, Poster presentation		
15:15- 16:00	Modern Hoof Care Management	Arturo Gomez	Jan Shearer
16:00- 17:45	Hoof treatment needs an approach without Antibiotic	Jan van Geest	Jan Shearer

Scientific program of the first Regional Conference on Cow Comfort and Lameness (RCCCL)

Thursday, May 12, 2016

Time	Topic	Lecturer	Panel
9:00- 9:45	Effect of heat stress on milk production, fertility and health of dairy cows in Tehran Province, Iran.	Arya Badiei	Richard Laven
9:45- 10:30	Reducing lameness in dairy cows: Working with farmers to manage lameness	Helen R Whay	Richard Laven
10:30-11:15	Coffee Break, Poster presentation, Commercial Exhibition	-	-
11:15- 12:00	Managing the transition from pasture to housing- the new zealand experience	Ricahrd Laven	Helen R Whay
12:00- 12:45	Cow handling and its importance in preventing lameness	Shahab Ranjbar	Helen R Whay
13-14:45	Lunch, Poster presentation		
14:45- 16:30	Hoof care session Study on annual and seasonal lameness prevalence in dairy cattle herds of kermanshah province: the first comprehensive study Evaluation of the culling rate in cows with interdigital necrobacillosis	Ali Ghashghaei Mojtaba Mohamaddoust	Ali Ghashghaei



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