



# LAMENESS IN RUMINANTS

Embracing Excellence in Mobility and Wellbeing

CONFERENCE 2022

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**2022 Proceedings**



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## Welcome

The Organizing Committee of the 21<sup>st</sup> Symposium and 13<sup>th</sup> Conference on Lameness in Ruminants would like to welcome you to beautiful Bloomington, Minnesota. On the outskirts of Minneapolis, a metropolitan city in the upper Midwest United States, the state of Minnesota contains endless natural beauty, the headwaters of the mighty Mississippi River and some of the largest, most innovative dairy farms in the United States. The past few years have brought unprecedented events and hardship around the globe. We are very happy that you are able to join us for Lameness in Ruminants 2022. Whether it is your first time attending or your 21<sup>st</sup>, welcome!

This international program has been carefully selected to present the latest information and best practices for “Embracing Excellence in Mobility and Wellbeing.” The conference will feature a variety of talks, poster presentations, interactive panels, and summary discussions. Monday and Tuesday pre-conference, hands-on workshops will give participants a chance to hone skills in communication for client motivation, fundamental and advanced techniques in hoof trimming, and the role of nutrition in hoof health. The three-day program begins Tuesday afternoon with an interactive lameness case study presentation of a real, on-farm problem to kick start the participant discussion. Wednesday and Thursday sessions have been split into research and applied tracks, with each segment concluding with an interactive summary or panel discussion. Wednesday’s research track features keynote speakers on data use to embrace excellence in mobility and then moving on to trimming and wound healing in the late morning and afternoon sessions. The applied track will focus on lameness issues in beef and feedlot cattle. Thursday morning’s keynote kicks off again with communication strategies, followed by communication abstracts and the small ruminant presentations in the research track. The applied track on Thursday will be hoof trimmer focused, with keynote presentations on footbaths, panels on trimming programs, and short talks on claw mechanics. The closing keynote will be given by Jennifer Walker from Danone, giving a processor’s perspective of “Excellence in Mobility.” Friday’s post-conference workshops will offer participants a tour of local, innovative, high-production dairies or a multi-session, hoof trimming workshop in a fun and interactive format.

We hope to offer not just new information, techniques, and best practices, but also ample time to meet with old colleagues and meet new ones. The heart and soul of this conference is the unique and diverse background of its participants and the shared visions for treating lameness.

We would like to take a moment and thank our sponsors and exhibitors. Their generous support makes it possible to put together this great program. We would also like to acknowledge and thank our scientific reviewers. Their assistance in reviewing abstracts helps maintain the high standard of scientific rigor that makes this the premier conference that it is.

The organizing committee hopes that you enjoy your stay in the greater Minneapolis area and that you get a chance to spend some time traveling in the United States, before making your journey home. We hope you enjoy the program we have prepared for you.

Best wishes and safe travels! Until the next conference.

**Lameness In Ruminants Conference 2022 Organizing Committee**



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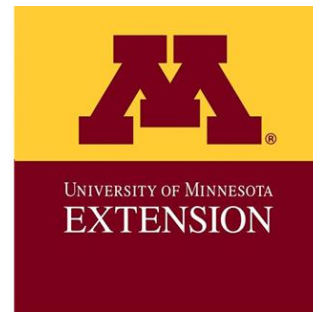
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# **Development and use of a graphical user interface showing claw health at herd level**

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## Objectives

To monitor claw health and evaluate claw health management interventions at farm level, it is important to have valid and consistent recordings of claw trimming and tools that can provide an overview and details of the recordings. While digital recordings of claw trimming and claw lesions are already possible for Danish farmers, the objective for this project was to develop an interactive graphical user interface (GUI) to show a claw trimming profile and an interactive GUI to present claw lesions at farm level. Also, the use of the two GUIs will be addressed.

## Material and methods

Initially a workshop, where farmers, claw trimmers, bovine veterinarians, cattle production advisors, and researchers attended, provided an outline of functions needed in a GUI. A draft version of the GUI was created using a software application (Microsoft Power Business Intelligence (Power BI), Microsoft ©). The draft version based on anonymized claw recordings extracted from the Danish cattle data base (DCDB) was tested by user groups consisting of farmers, bovine veterinarians, and cattle production advisors. Adjustments were made and the GUI was incorporated in the Dairy Management System (DMS), a digital management tool provided to the cattle farmer by SEGES. The claw health GUI was launched in two steps: a claw trimming profile in September 2020 and a claw health interface in September 2021. Trimming and lesions can be recorded using the common Nordic claw recording system, (Nordic Claw App, Anonymous, 2022), by a smart phone or by using DMS. All data are uploaded to DCDB. Descriptive statistics showing how many times the GUI has been used for the first four months after second launch was collected at February the 7<sup>th</sup>, 2022, using a DMS statistic function.

## Results

The claw trimming profile shows the proportion of animals (heifers and cows) trimmed in relation to calving. It is divided in two sections, where the first shows the proportion of animals trimmed in relation to days before calving and covers the period 0-100 days before calving. Animals calved within the last 12 months are included. The second section shows the proportion of cows trimmed 1-4 times in relation to days after calving. Only trimmings within the last 12 months are included. The Danish recommendations for claw trimming at 60-80 days before expected calving and at 60-90 and 180-210 days after calving (Raundal, 2020) are also shown. A sorting function is included so it is possible to view all animals or view parity groups separately from parity zero to third and above.

The claw lesion GUI shows recorded trimmings and claw lesions in the herd and has a variety of dynamic functions providing an overview or details of, among others, specific lesions, parities, periods, and lactation stages. For each type of lesion, a short list of recommendations for controlling the lesion can be shown. Also, cows with repeated lesions can be listed.

The descriptive statistics revealed that in the four-month period after second launch the GUI had been used 1,258 times in 422 unique herds corresponding to approximately one third of the dairy herds that record claw trimmings and lesions digitally. The GUI had been used by veterinarians (443 times), farmers (420 times), cattle productions advisors (130 times) and others (265 times).

### Conclusions

The development of the claw GUI was based on necessary functions defined by the principal end users, that is, farmers, veterinarians, and cattle production advisors. Also, these groups were included in testing panels during formation of the GUI. The GUI is intended to be used 2-4 times a year, so a relatively high proportion of herds that have been using the GUI in the first four month. This could be a result of the incorporation of the end users in the development process. A third function of the GUI, showing the impact of claw lesions on production parameters such as milk yield, reproduction, and risk of culling at farm-specific level is under construction.

### References

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Raundal, PM. Landbrugsinfo. 2020. Tjek i DMS, om I klovbeskærer køerne på de bedste tidspunkter (landbrugsinfo.dk) (in Danish).

# **How do different frequencies of outdoor access influence the gait and hoof health of non-clinically lame cows housed in a movement restricted environment?**

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## Objective

The objective of our study was to evaluate the effects of 1 vs 3 days per week of access to an outdoor exercise yard on gait and hoof health of non-lame cows housed in tie-stalls as a model of cows kept in a movement-restricted environment. Our previous study utilized a similar design but with different treatment groups (1h 5d/week outdoor access vs. no outdoor access) and demonstrated an overall gait improvement of 1 score in cows receiving 5 weeks of outdoor access. Based on this, we hypothesized that providing lower frequencies of outdoor access for movement-restricted cows would also yield levels of positive outcomes on gait. We also hypothesized that provision of outdoor access will not lead to any detrimental effects on hoof health.

## Materials and methods

Thirty-six lactating Holstein cows housed in tie-stall were enrolled in the study and blocked by parity and DIM (n=6/block). Cows were randomly assigned to one of two exercise treatments: cows receiving outdoor access for 1h/d 1d/week (Exercise1x) or 3d/week (Exercise3x) for 5 weeks. Overall gait and 6 gait attributes (swinging out, back arch, tracking-up, joint flexion, asymmetric step and reluctance to bear weight) were assessed by one observer using a 5-point visual gait scoring at three data collection periods: before the start of the study (Pre-trial), at the end of the study (Post-trial), and 8 weeks after the end of the study (Follow-up). Clinical assessment of claw lesions was conducted during hoof trimming at Pre-trial and Follow-up. Number, location and severity score of claw lesions were recorded. Overall gait, gait attributes, and severity of lesions were analysed using linear mixed effect models ( $\alpha < 0.05$ ), whereas lesions were analysed using mixed effect logistic regression models ( $\alpha < 0.05$ ).

## Results

The average gait score for cows in Pre-trial, Post trial and Follow-up were 2.13 (Min: 1.5, Max: 3.5), 1.98 (Min: 1, Max: 3.5) and 2.02 (Min: 1, Max: 3), respectively. Regarding cows that scored  $\geq 3$ , there were 3 in the pre-trial, 3 in the post-trial, and 2 in the follow-up period. There were no statistically significant differences for the changes in overall gait and gait attribute scores between the treatment groups and periods ( $P > 0.05$ ). Throughout the experimental period, the observed change in the overall gait score was  $-0.13 \pm 0.18$  and  $-0.13 \pm 0.17$  for Exercise1x and Exercise3x, respectively ( $P > 0.05$ ). Sole (n=39, average severity score =  $1.26 \pm 0.36$ ) and white line hemorrhages (n=2, average severity score =  $1.5 \pm 0.29$ ) were the only claw lesions observed. Between Pre-trial and Follow-up, the prevalence of claw disorders did not change ( $P > 0.05$ ) for Exercise1x (5.56% to 6.62%) or Exercise3x (9.72% to 6.94%). Similarly, the severity scores of claw lesions were not statistically different between treatment groups and periods ( $P > 0.05$ ).



## Conclusion

Contrary to our hypothesis, the preliminary evaluation of gait in the current study showed that changes in gait scores for cows provided with 1h 1d/week or 3d/week are negligible. It suggests that lower frequencies of outdoor access may not be sufficient to benefit gait compared to 1h 5d/week outdoor access. However, given that we did not target clinically lame cows upon enrollment, the small changes in gait that may occur between treatment groups over the 5-week application period may not be recognizable by visual gait scoring alone. Therefore, to precisely determine the impact of providing outdoor access on gait, kinetic and kinematic measurements of gait have been acquired through a pressure mapping system and a 3D motion analysis system for further analysis. The results of claw lesion assessment corroborated our previous study and showed that lower frequencies of outdoor access had little impact on claw lesions development in movement-restricted cows. However, to detect hoof pathologies at early/subclinical stages, the analysis of thermal images of cow's hooves is currently underway.

# **Using 3D-kinematics in conjunction with machine learning approaches to predict dairy cow locomotor ability**

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## Objectives

Lameness is a prevalent issue within the dairy industry that has serious financial and welfare implications. Traditional locomotion scoring systems conducted by a visual observer, such as a numeric rating system (NRS), provide a simple way to assess dairy cow gait; however, this method is prone to low reliability and is relatively subjective when compared to more automated approaches for assessing lameness. The objective of this validation study was to determine if kinematic data acquired for 20 specific joints on a cow when walking could be used with machine learning approaches to predict a locomotion score with high accuracy. Specifically, in continuation of previous work using similar kinematic data with a Convolutional Neural Network (CNN), we aimed to develop a model with Long Short-Term Memory (LSTM) architecture that could predict locomotion scores of dairy cows from kinematic data. The hypothesis was that kinematic data would reflect the gait quality of cows that was visually observed through locomotion scoring.

## Materials and methods

The 3D-scaled coordinates of 20 specific marked joints on the cow were acquired through a kinematic system consisting of six video cameras and a motion tracking software. Seventy-four recorded passages, in which a cow walked the duration of a 7m designated walkway, from among 12 cows were retained for analysis and processed. Locomotion scoring was conducted according to a 5-point NRS scale with 0.5 intervals (9 gait classes) in which a score of 1 represented the highest quality locomotion, a score of 3 or higher represented clinical lameness, and a score of 5 represented severe lameness. A trained observer assigned scores for individual passages using corresponding video recorded through the kinematic system. Ultimately, across all passages, assigned scores represented 4 consecutive classes of gait quality ranging from scores of 2 to 3.5.

For model validation and testing, kinematic data for 25% ( $n = 19$ ) of the total passages were held aside to create a validation set, with the remaining 75% ( $n = 55$ ) used as a training set. A data augmentation strategy was implemented to generate synthetic samples to expand the training dataset; random noise was added to motion trajectories from the training set with varying magnitudes of 1 % or 5% of the original value to stochastically determined rows. The number of artificially created passages varied for each NRS class to create two balanced final training datasets with 2,500 samples of each gait category, resulting in a total of 10,000 training passages with either 1% or 5% added random noise. Two overall types of models, CNN and LSTM, were tested, with each having 4 versions tested: 1 layer in the model architecture with 1% variation in the augmented data, 1 layer with 5% variation, 2 layers with 1% variation, and 2 layers with 5% variation. Performance metrics including accuracy, precision, recall, and F1-score were used to evaluate the models.

## Results

All tested models performed well on the training data accuracy but poorly on the validation data. The LSTM (2 layer, 5% var) model performed best on the performance metrics of precision ( $0.378 \pm 0.106$ ) and F1-score ( $0.299 \pm 0.067$ ). The LSTM (2 layer, 5% var) and the CNN (1 layer, 5% var) models had the best accuracy ( $0.403 \pm 0.109$  and  $0.403 \pm 0.031$ , respectively) of all the models. The CNN (1 layer, 5% var) model had the highest recall ( $0.327 \pm 0.029$ ) out of all models.

## Conclusions

In this validation study, 3D kinematic data did not reflect what was visually observable by the individual conducting locomotion scoring to the extent that specific locomotion scores could be predicted with a high accuracy using CNN and LSTM models. Kinematic data provides an ideal starting point for the development of a model that could predict dairy cow locomotor ability, but more research is needed to use this data to its fullest potential. Such models would be beneficial for both on-farm and research purposes, as it would allow for earlier detection of locomotor impairment and would not involve the time commitment, training, and low reliability that is often associated with visual locomotion scoring.

# **An evaluation of early intervention protocols based on camera-based autonomous mobility score trends**

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## Objectives

The objective of this project was to determine if changes in camera-based autonomous mobility scores could be used to reduce the duration of lameness.

## Materials and methods

Starting in July 2021, a 2300 cow herd was scored continuously using camera-based autonomous mobility scoring (CattleEye). The camera-based mobility scoring (CMS) outputs a score of 0 to 100, where 0 indicates no mobility abnormalities and 100 indicates severe mobility abnormalities. A score above 49 is considered lame. At the same time, the herd's hoof trimmers were trained in nomenclature for the recording of lesions and their hoof trimming technique was standardized. Starting in December 2021, cows with an increasing CMS trend over the previous 14-day period were enrolled in the study on a weekly basis. This increasing trend was determined based on a linear model of the CMS that gave each cow a trend score. Cows with trend scores above 20 were eligible for enrollment. To ensure only new cases of lameness were enrolled only cows with a CMS below 50 in 14-28 days before enrollment were eligible for enrollment. Additional enrolment criteria included cows being greater than 14 days in milk, not being coded as 'do not breed', and not having a concurrent illness. These data were retrieved from the farm's on farm management software. Eligible cows were scored by trend score from highest to lowest and odd numbered cows were placed on the hoof trimming list (TEST). Even numbered cows were enrolled in the study but not placed on the hoof trimming list and were considered our CONTROL group. Due to hoof trimming capacity, between 5-12 cows with the highest trend scores were placed on the farm's hoof trimming list and an equal number of CONTROL were enrolled. Our outcome of interest was percentage of days cows spent about their maximum score during the 14-day pre-enrolment window. Due to ongoing enrolment, our initial analysis only included a 14-day post enrolment window. Data was analyzed by comparing means and using a linear model that included, treatment, lactation group, days in milk, trend score and max score at enrollment as confounders.

## Results

At total of 128 cows were enrolled in the study with 65 cows in the CONTROL group and 63 cows in the TEST group. In the CONTROL group 22, 18 and 28 cows were in the 1<sup>st</sup>, 2<sup>nd</sup>, or 3+ lactation categories respectively. In the TEST group 22, 12 and 30 cows were in the 1<sup>st</sup>, 2<sup>nd</sup>, or 3+ lactation categories respectively. Average days in milk at enrolment was 144 (95% CI 103-150) and 144 (95% CI 120-167) for the CONTROL and TEST group. Control cows had on average 16% of their scores above their max pre-enrolment score whereas TEST cows had 8% of their scores above their maximum pre-enrolment score. When these results were adjusted for possible confounders in our linear model results indicate that TEST cows spend 7.7% (95% CI 0-16.1) less days above their max pre-enrollment score.

### Conclusions

Our results support that early intervention based on increasing CMS trends improves the mobility of cows in the 14 days past enrollment.

# **Evaluating the correlation of digital dermatitis infection and genetic variants to predict gene resistance in lactating Holstein cattle**

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## Objective

Digital Dermatitis (DD) is a contagious bacterial hoof infection. Discovery of genetic resistance to DD will allow dairy producers to select for this trait, therefore reducing lameness caused by DD infections. This study evaluated the correlation of DD infection and genetic variants to predict genetic resistance to DD in Holstein cattle on a commercial dairy farm in central Texas.

## Materials and methods

Lactating dairy cattle were scored on a 0 (no lesions present) to 4 (chronic lesions) scale. Blood samples were collected on lactating cows (n = 45) from the coccygeal vein. Cows were identified as having a lesion (n = 35) and not having a lesion (n = 10). Genomic DNA was isolated from 200 uL of whole blood, Genomic DNA was purified from whole blood samples from (n = 45) lactating cows. Four previously reported SNPs were evaluated to determine correlation to DD resistance by qPCR melt curve analysis. SNPs in the 3'UTR of *Interleukin-8 (IL8)* and in exon 3 of *Toll-Like Receptor 4 (TLR4)* were analyzed by Chi-Square in SAS (Version 9.4 SAS Institute, Inc., Cary, NC) to determine the frequencies of different genotypes present amongst the resistant and affected animals.

## Results

Chi-Squared test of Bta-IL8 Exon 3 SNP resulted in a probability value of 0.0382. However, Bta-T4CRBR2, and Bta-T4CRBR1 SNPs that demonstrated no detectable variants within the populations, so no analysis on resistance could be performed. These results indicate a genetic correlation to resistance to Digital Dermatitis within the *IL8* gene in Holstein cows.

## Conclusion

This work can lead to a genotyping assay to select for cows genetically resistant to Digital Dermatitis.

# **Exploring the use of sound-based methods for lameness detection in dairy cattle**

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## Objective

The objective of this exploratory study was to develop a sound measurement system to investigate the use of acoustics to detect lameness in dairy cattle.

## Materials and methods

This study was completed at the Southwest Regional Dairy Center (Tarleton State University, Stephenville, TX) with crossbred dairy cattle ( $n = 10$ ). Cattle were scored as either lame or non-lame in an effort to simplify the scores during this exploratory experiment. Five cattle were scored as lame and five cattle were scored as non-lame prior to walking past the sound system. Cattle were pushed past the stationary sound system in the exit alley. The sound system included a directional condenser microphone with a frequency response of 20Hz to 18kHz. The audio signals were recorded using a 24-bit/96kHz Zoom H6 handheld recorder. The data from the digital recordings were analyzed using the signal processing tools in MATLAB®. Fourier analysis was performed on the data, which is a common technique for processing digital signals to identify any distinguishing characteristics. Our analysis was focused on evaluating the power spectrum, along with the single-sided amplitude spectrum, for each of the audio signals and comparing them together for any prominent differences.

## Results

The analysis in the frequency domain was focused on the frequency range 300 Hz and below. Most of the signal power was in that particular range. There were differences found in the audio recordings for lame and non-lame cows. However, those differences were quite subtle and complex to detect. These differences also appear to be concentrated in the region of low frequencies which may explain the reason for the complexity due to its high susceptibility to noise. The lack of dominant and distinguishing features may also be due to the mechanism employed for recording the audio, the chosen analytical techniques, and the number of recordings were insufficient to conduct a thorough analysis.

## Conclusions

The current findings demonstrate the need for an increase in sample size. While the use of a stationary microphone for audio recordings has merit, the stationary system may have contributed to the weak finds and the signal strength may have been influenced by the cow's natural shift in position as they moved toward and away from the microphone. Further research is needed to strengthen this concept.

# **Deviation in mobility patterns as an early indicator of lameness in dairy cows using sensor technology**

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## Objective

An early warning system could help identify and treat lame cows in time to minimize the use of antibiotics and pain from the cow. However, a sensible measure for classifying early lameness has not yet been reached with the available automated systems. Inaccurate and insufficient mobility data remain a major limitation for the development of a reliable and practical system. The available automated systems are limited to information from full-blown lame cows recorded by a single sensor. A single sensor data is inefficient in discriminating some of the mobility characteristics that could be used for lameness classification. The objective of this study is to use multiple sensors concurrently to develop an early lameness warning system.

## Materials and methods

During spring to early autumn, 6 dairy farms were visited in the South of Wageningen. Approximately 94 cows that were either healthy, lame, or healthy and later became lame were equipped with sensors. Data on mobility characteristics were obtained through a combination of a neck-mounted accelerometer and GPS sensors on each cow for a week. During the process, visual behavioural observations were also undertaken using smartphone software and an ethogram for behavioural classification. The dataset attained through the various sources was then used for statistical analyses. During these analyses, prediction models were developed using either single or integrated datasets through various machine learning techniques.

## Results

Based on our observations, healthy and unhealthy cows behaved differently, therefore, differences in behavioural patterns between the cow groups are expected, e.g., lame cows will be less active compared to healthy ones, and lie more and graze less. These behavioural changes are also expected to steadily de/increase in cows that were initially healthy and later became lame. The model integrating all different data sources is expected to show improved classification accuracy, especially in the early stages of lameness.

## Conclusions

Several studies have already shown the potential of a single wearable sensor to replace visual observations. However, integrated data could further improve automated lameness classification, and reduce single sensor limitations.



# **Sonographic imaging of digital fat cushions during the first three lactations of dairy cows**

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## Objective

Hoof diseases are a common cause of economic losses on dairy farms. They are a reason for decreased performance, high veterinary costs, or even culling of animals (1-3). By early diagnosis of pathologic changes, it is possible to improve hoof health and ultimately animal welfare of dairy cows (4). In this context, sonography as a diagnostic method shall be tested.

Emphasis is placed on the examination of the subcutaneous digital fatty cushions. This tissue is subjected to changes in terms of thickness during a single lactation (5). The objective of this investigation is to analyze the dynamics of thickness in digital cushions over a period of three lactations. Furthermore, correlations between fat body thickness, body condition and changes in blood values will be investigated as well as the relation of these measurements with pathologic changes causative of hoof diseases. A secondary aspect and experimental part of the study is the preparation of hooves for histological sections.

## Materials and methods

80 cows from 3 dairy farms in Thuringia and Lower Saxony are regularly examined during three lactations (1st-3rd lactation). Hooves of all animals were trimmed according to principles of functional hoof trimming. The examination protocol includes:

- estimation of physical condition (body condition score)
- measurement of body weight
- evaluation of gait pattern (locomotion score) (6)
- ultrasound measurement of back fat thickness
- ultrasound images of digital cushion (right hind lateral hoof, right front medial hoof)

Two positions are defined as standardized measurement positions in longitudinal ultrasound sections:

- thinnest dimension next to flexor tubercle
- thickest measurement at point of maximum concave curvature at solear surface

Additional measurements:

- cross-sectional image of fat body at each standardized point.
- length of digital cushions using solear markings on the hoof.

The structures of the hoof are then measured within the ultrasound images using the software ImageJ (NIH).

## Results

Data evaluated so far show a dynamic change in digital cushion thickness during first lactation. Maximum values are reached shortly before calving. The average value around day 220 of gestation on front hooves was 7.2mm at the flexor tubercle [minimum-maximum (min-max): 4.2 13.2mm) and 10.0mm at the thickest part (min-max: 6.3 13.4mm). On hind hooves, the average value at the flexor tubercle was 5.8mm (min-max: 3.8 12.0mm) and 9.2mm at the thickest part (min-max: 5.2 14.9mm).

Within the first week after calving, the measurements drop: the average value of front hooves at the flexor tubercle was 5.8mm (min-max: 3.6 9.9mm) and 9.2mm at the thickest part (min-max: 5.8 11.8mm). At the hind hooves the average value at the flexor tubercle decreased to 5.7mm (min-max: 3.7 11.9mm) and to 8.6mm at the thickest part (min-max: 6.4 11.0mm). In some cases, the values even dropped to levels less than the thickness of the fat cushions at the beginning of the examinations.

A correlation between digital fat pad thickness and back fat thickness is becoming apparent, too.

### Conclusion

Sonography as a diagnostic method on the hoof is a suitable and practical instrument. It allows to visualize the digital fat pads in most cases and enables the examiner to take measurements of its actual thickness and length. Thus, long-term observations of changes within hoof tissues offer the possibility to better understand pathologic alterations leading to hoof diseases like sole ulcer. Furthermore, statements about physiologic / pathologic conditions of the distal phalanx (e.g. fractures) as well as the deep digital flexor tendon are possible.

A positive correlation between the general body condition and the thickness of the fat body of an animal can be assumed. Analysis on the exact chronological course of fat body thickness, as well as on the hypothesis that a thin fat pad could be indicative for future development of a hoof ulcer, is still to be investigated.

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# **Preliminary evaluation and progress in the incorporation of camera-based locomotion scores and hoof lesions into a national database**

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## **Objectives**

Provide preliminary data from a pilot study investigating the use of a video analytics platform (CattleEye) to score locomotion in dairy cows in conjunction with lesion data collected with hoof trimmer and herd management software. The ultimate objective of the project is to utilize these data for on-farm management of hoof health as well as flow into a pipeline providing data to be used for genetic evaluations.

## **Materials and methods**

To date, 464,360 locomotion scores (LS) have been collected routinely on a large, primarily Holstein herd from 4,047 unique cows beginning in July 2021 using the video analytics platform. Scores range from 0 to 100 with scores greater than 50 being considered lame by the platform based on a validation study. Additionally, specific lesion data are collected from hoof trimming sessions and combined into herd management data, including digital dermatitis (DD), ulcer, white line diseases (WLD), foot rot (FR), toe (includes thin soles/toe ulcers), corkscrew claw (CC), injury (LEG), or other hoof problems (OTHER). Collected data also indicate the affected limb. Unique events collected from January 2020 to 2022 total 101,021 with 968 coded as a lameness (LAME) event and 8,598 coded as a hoof trimming (TRIM) event. Associated lactation data were acquired from the United States National Dairy Cooperator database. These data allowed for cross-checking animal identification, birthdate, calving date, and parity.

## **Results**

Locomotion scores were found to have a mean value of 35.6 and standard deviation of 12.9 points. Lesion data collected from hoof trimming sessions included 333 WLD, 207 ULCER, 205 DD, 74 TOE, 73 FR, 13 CC, 10 LEG, and 3 OTHER records. Limb affected was reported as 44% left rear, 24% right rear, 16% left front and 14% right front. Additional records did not conform to reporting specifications but were found to be reported prior to implementation of current protocols. Among animals with a LAME event reported and an associated locomotion score on the event date, average locomotion score was over 12 points higher (47.9) than the average LS. Comparatively, among animals with a TRIM event reported and an associated LS on the same date, average locomotion score was approximately the same as the full LS data (35.9). Breaking out LAME events by specific lesion, those with higher mean locomotion scores were TOE (51.0) and ULCER (50.2). Digital dermatitis had the lowest mean locomotion score equal to 39.4, although still greater than the herd's overall average score.

## **Conclusions**

There are hurdles in gathering and combining these different types of data. Collection is on-going to increase the amount of data available. Further work is needed to identify the relationship between the locomotion scores produced by the video analytic platform and specific lesion records; however, preliminary results indicate higher locomotion scores associated with hoof lesions. These data are currently proving useful for herd management purposes. Next steps include combining these data with available lactation and pedigree information for preliminary genetic analyses.

# **Bluetooth-enabled multimodal sensor boards, data collection software stack, and machine learning model to identify early signs of lameness in dairy cattle**

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## Objectives

To demonstrate the use of custom electronic sensor boards with software stack to automatically collect real-time movement data from multiple cows and to develop a machine learning model to process the collected data for the identification of early signs of lameness.

## Materials and methods

We developed an electronic sensor board incorporating state-of-art sensors, including 3-axis accelerometer and gyroscope, electret microphone and infrared temperature sensor. Each sensor board was controlled by an on-chip, Bluetooth-enabled 2.4 GHz Nordic Semiconductor microprocessor and powered by a 3.3 volts, 800 mAh coin cell battery. A software stack was built in Python and included modules to wake up specific sensor boards, activate the desired sensors, collect the data for a pre- specified time duration, and store the recorded data in user-defined file formats. The performance of each sensor, the sensor boards, and the software stack was characterized in an Electrical Measurement Laboratory over several days to evaluate different performance metrics, such as sensitivity, resolution, temperature range, amplitude range, frequency and range of operation, power consumption, and battery life. The sensor boards were attached to both ear pinnae of individual cows to record multimodal sensor parameters, such as head acceleration, head rotation, head tilt, vocalization, ear skin temperature, and ambient temperature. A local server communicated with the sensor boards on ten cows to collect data from individual sensors every one second within an operating range of 50 to 100 feet. Video recordings from portable camcorders were collected for select time durations to externally validate the data recorded from sensor boards.

## Results

The sensors' data stored in the local server were preprocessed and sorted according to the individual cows being monitored. Data labelling was performed in the presence of an expert. The training data set was fed into a machine learning model to train the model to identify instances of abnormal movement and head raising. The importance of the different sensor parameters was ranked based on their role in predicting instances of abnormal movement and head raising. Other behavioral indicators of interest being investigated for training the model include the instances of faster breathing, distress vocalization, and elevated skin temperature. The sensor boards were modified to focus on the more informative parameters for detecting early signs of lameness, including changes in the data resolution, frequency of data collection, and data processing algorithm. A web-based software app is being developed to display the model predictions as an automated decision support tool for farm caretakers and users.

## Conclusions

Movement-based data was collected remotely from multiple cows using the Bluetooth Low

Energy communication protocol implemented in custom electronic sensor boards and Python-based software stack. We developed a machine learning training model and identified the informative parameters indicative of early lameness. This allowed us to tune the data collection and modelling steps towards developing a farm-deployable, non-invasive, continuous monitoring tool for health and welfare risks of individual cows.

# **Audio signal analysis of cow vocalizations in Python's Librosa with gradient boosting algorithms to identify abnormal sound signatures in lame cows**

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## Objectives

Develop methods to record high-quality audio data from individual cows, investigate platforms to preprocess the audio signals, and build machine learning tools to identify abnormal vocalization.

## Materials and methods

Raw audio data was collected from individual cows in dairy farms using the Zoom H4n Pro Handy Recorder. This series of Zoom recorders has sophisticated capabilities for field recording, such as XY microphones, preamplification modules, and enhanced noise cancellation. Each audio recording was captured for around 30 seconds and saved in a .wav file format within a local server. All the saved data were initially screened to discard the audio recordings of poor signal quality. Thereafter, data labeling was performed in the presence of an expert to label the audio recordings into different categories. The next stage was data preprocessing which included the steps of label encoding, feature scaling and database split (into Test, Train and Validation Sets). All models were built using python3. For our model development, we used Librosa which is a powerful Python package for music and audio signal analysis.

## Results

The preprocessed audio data was fed into Librosa to extract several features, such as Short Time Fourier Transform (STFT), Inverse Short Time Fourier Transform (ISTFT), Instantaneous Frequency Spectrogram (IFGRAM), Mel Spectrogram, Chromagram, and Tonnetz representation. We investigated in-built tools available for music and audio signal processing, such as ways to estimate the tempo and positions of beat events, along with parameters to optimize the sampling rate, frame rate and hop length. Power spectrum analysis was performed on the labelled audio recordings to estimate the spread of signal power across the frequency band. We applied a non-parametric approach based on both time-domain analysis and frequency-domain analysis. The Mel spectrograms were visualized. Subsequently, machine learning models were developed with the extracted features. The training data set was fed to machine learning models for appropriate classification of the audio signals, such as normal vocalization or pain-related vocalization. We applied Xtreme Gradient Boosting (XGB) and Light GBM (Gradient Boosting Method) for the sound classification. A web interface was used to visualize the audio recordings in time and frequency domains and display the prediction outcomes from the models. We achieved reasonably high accuracy with our fine-tuned XGB model for sound classification. The Light GBM achieved better accuracy with less execution time. As such, our initial results indicate that the Light GBM is a better classification model for processing large audio datasets and for real-time, on-farm edge computing applications.

## Conclusion

Built on the Python's Librosa software package, we demonstrated an audio signal processing framework that is applicable to the dairy industry, particularly to identify abnormal cow vocalizations related to pain, distress, or lameness. We described methods for audio recording, labelling, preprocessing, feature set extraction, visualization, sound classification, and model development. Our results indicate that the available classification tools currently being used in other machine learning applications, such as the Light GBM, are capable of predicting abnormal cow vocalizations with reasonable accuracy.

# **Broad-spectrum infrared thermography for detection of M2 digital dermatitis lesions on hind feet of standing dairy cattle**

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## Objectives

Test the association of infrared thermography (IRT) measurements with M2 lesions under farm conditions, with the ultimate goal of lesion detection.

Primary objective of this study was if broad spectrum IRT effectively detected M2 lesions on unwashed hind feet of cows standing in a milking parlor. As secondary objectives, we also investigated the association of IRT with M2 lesions on pre-washed hind feet of standing cows and the association of IRT with the presence of any digital dermatitis (DD) lesion on unwashed and washed hind feet of standing cows.

## Material and methods

Thermal images were collected from the plantar aspect of 529 unwashed and 558 washed hind feet of cows from 5 different Canadian dairy farms. After washing, the feet were also M-scored while being in the milking parlor. From these feet 205 unwashed and 229 washed feet also had a locomotion score and lower leg cleanliness score available.

The association between maximum IRT values and the presence of M2 lesions was assessed using multivariable logistic regression analysis. The dependent variable was M2 lesion (1 = present, 0 = absent) and independent variables were maximum IRT, cleanliness score, and locomotion score. Farm was fixed into the model as a mean to account for farm effect and clustering of cows within farm. The final reduced model was based on the lowest Akaike information criterion using a backward elimination approach.

This multivariable logistic regression analysis was repeated with any DD lesion (1 = present, 0 = absent) as dependent variable.

## Results

Higher maximum IRT values were associated with an increased odds for M2 lesions on both unwashed and washed hind feet, as was presence of dried manure on the lower hind legs. Higher maximum IRT values were associated with an increased odds for DD presence on both unwashed and washed hind feet.

## Conclusion

The presence of M2 lesions on hind feet was associated with higher maximum IRT values of the plantar aspect of the pastern region, both on unwashed and wash feet of standing dairy cattle. For conditions with a low true prevalence, which generally is the case for M2 lesions, diagnostic tests with a very high specificity are needed. It is unlikely that cut-off values of IRT max can achieve this. Maximum infrared temperature does have a potential role in identifying feet at-risk



for poor foot health that need further checking and thereby is a tool that can aid in the automation of monitoring the foot health status on dairy herds.

Preliminary results were presented at the European Bovine Congress 2019, 's Hertogenbosch, the Netherlands.

# **Investigating the effectiveness of 1 hour daily outdoor access on the gait and hoof health of non-clinically lame cows housed in a movement-restricted environment**

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## Objectives

The objective of the study was to evaluate how regular access to an outdoor exercise yard affects gait and hoof health of non-lame lactating Holstein cows housed in tie-stalls – a movement-restricted environment. We hypothesized that provision of outdoor access for movement-restricted cows will result in higher step activity and improvements in gait and movement ability. Furthermore, we hypothesized that outdoor access will not lead to any detrimental effects on hoof health – measured based on prevalence and/or severity of claw lesions and hoof surface temperatures.

## Materials and methods

Thirty Holstein cows (average gait score: 2.17, Min: 1, Max: 3.5), blocked by parity and DIM (n=6/block), were randomly assigned to one of two treatments: Exercise (1 h/d, 5d/wk of outdoor access for five weeks) and Non-Exercise (no outdoor access). Step activity was continuously recorded during the trial using pedometers. Six gait attributes and overall gait were assessed via visual gait assessment using a 5-point scale at three data collection periods: before the study started (Pre-trial), study end (Post-trial), and 8 weeks post-trial (Follow-up). Hoof health was evaluated by claw lesion assessment and hoof surface thermography. Number, location and severity of claw lesions were recorded during hoof trimming at Pre-trial and Follow-up. Infrared thermal images were taken from the dorsal view of coronary band (CB) of all hooves at week 1 and 5 of the trial and four temperature variables were extracted from the CB area. Step activity, overall gait, gait attributes, severity of claw lesions and hoof thermography data were analysed using linear mixed effect models ( $\alpha < 0.05$ ). Claw lesion was treated as a binary variable and was analyzed using a mixed effect logistic regression model ( $\alpha < 0.05$ ).

## Results

Step activity did not differ between treatments; however, Exercise cows tended to express higher steps activity than Non-Exercise cows ( $705 \pm 71.4$  vs  $518 \pm 67.9$  steps/d, respectively,  $P = 0.07$ ). There was no statistically significant difference between treatments or periods for changes in scores for overall gait or gait attributes ( $P > 0.05$ ). However, Exercise cows showed a numerical improvement in the overall gait score (2.78 vs 1.78, Pre-trial vs Post-trial, respectively) and 3 key gait attributes after 5 weeks of outdoor access at Post-trial. The improvement in gait persisted at Follow-up. A total of 38 claw lesions were observed at the two data collection times (Pre-trial and Follow-up) and all the lesions were sole hemorrhage. The prevalence of claw lesions did not change between Pre-trial and Follow-up for Exercise (7.50% vs 6.67%;  $p = 0.58$ ) or Non-Exercise cows (10% vs 8.04%;  $P = 0.16$ ). Similarly, there was no impact of time or treatment groups on the severity of claw lesions ( $P > 0.05$ ). Hoof thermography analysis showed

no significant alteration in CB area temperature variables between treatment groups and times ( $P > 0.05$ ).

### Conclusion

The positive effects of outdoor access application on gait scoring were in accordance with our hypothesis. By design, the study did not target cows that were clinically lame or had severe claw lesions upon enrollment. Despite this, movement-restricted cows that were provided with regular outdoor access in the Exercise group still showed a numerical improvement in overall gait scores and across multiple gait attributes. Nevertheless, the full impact of providing outdoor access on gait with the incorporation of kinematic technology for more detailed gait analysis is currently underway. The results of claw lesion assessments showed little impact of outdoor access on the development of hoof pathologies which was in accordance with our hypothesis. The hoof thermography results also corroborated our claw lesion assessment. Further investigation is needed to look at what frequency or duration of outdoor access would still yield positive outcomes for non-lame dairy cows housed in a movement-restricted environment.

# **Video analytics for stance estimation of walking cows to identify visual signs of lameness**

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## Objectives

The goal of this project is to automate or facilitate the detection of lameness in cattle. To accomplish this goal, the objectives are to collect videos of walking cows, extract spatiotemporal features, and build a deep neural network to identify instances of cows' head raising, head drooping, and arching of the back.

## Materials and methods

We built a deep residual neural network inspired by current algorithms for stance (or posture) estimation of moving humans and animals. Video streams were collected from cows to build an audiovisual data repository for training and testing our model. The recorded videos were saved in .mp4 file format and transformed into skeleton sequences. The video data was preprocessed and cleaned to remove redundant segments. Each video was trimmed into smaller video frames using the 'TensorFlow Object Detection Application Programming Interface' and the 'OpenCV' programming platform. Image frames were extracted from the training videos and saved in a .csv file along with their corresponding tags. Data labeling was done in presence of an expert. The training dataset was created based on the Pandas data frames that contained the labelled information. The model was trained using the 'TensorFlow' open-source environment for subsequent estimation of cows' stance in the validation data set.

## Results

We used a marker-based system to label distinct key points on the body of individual cows, including the known markers of lameness such as the hooves, limb joints, and arch on the back. We extracted 24 key points from the image sequences of each video recording using a graphical user interface (GUI) written in 'wxPython' software. Additionally, we extracted coordinates along the cows' body during walking. The extracted key points and coordinates were used to generate the movement trajectories of the cows' left forelimb, left hindlimb, right forelimb, right hindlimb, pelvis, and head. The analyzed data was used to train the classification model and to obtain the class distribution. The model prediction has a normal distribution around the true labels for the different classes, suggesting that our model performed satisfactorily. The confusion matrix displayed the predicted values, actual values, and the precision of classification results. We also analyzed the confidence in classifying the different body parts. Most of the body parts achieved a high degree of confidence, especially the cow's nose and eyes. Thereafter, the probability of lameness for each limb was estimated and an overall lameness score was calculated. We tested our model on several videos of walking cows having varying degrees of image quality and resolution. The training/validation loss functions and accuracy curves were obtained for a dataset containing 1000+ samples, and a reasonably high accuracy was achieved. Our model gave the best prediction scores for videos having a single cow walking from left to right and the model's loss function was low in

these cases. We are currently working to address certain challenges in the present model, such as the difficulty in tracking multiple cows, analyzing videos with irregular cow movement, and differentiating between locomotion scores of 1 and 2 in cows.

### Conclusions

Our deep learning model was able to extract key features from video streams to delineate the visual indicators of lameness with reasonable accuracy, such as instances of cows' head raising, head drooping, and arching of the back. The amount and quality of video data had a significant impact on the model performance. There is scope for further refinement of the model with higher volume of good quality videos, particularly those depicting specific behavioral traits associated with lameness.

# **Comparative analysis of real-time object detection algorithms for digital dermatitis in dairy cattle**

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## Objectives

Digital dermatitis (DD) is responsible for ulcerative lesions on the interdigital space on the hoof and at the skin horn border on the coronary band of the claw. DD is associated with massive herd outbreaks of lameness and influences welfare and production. Early detection can lead to prompt treatment, reduce costs, and decrease lameness. The study aims to build an application for the real-time detection of DD in dairy cows. We compared various computer vision (CV) models for speed using inference time and for scoring using various performance metrics. The best model was automated for detection using downloaded and livestreaming video. We hope the tool can help to minimize the adverse effects of DD-associated lameness in all cattle by means of early detection, prevention, and prompt treatments.

## Materials and methods

Images were collected from commercial dairy farms facing the rear foot of the interdigital space of the hoof. Images were scored by a trained investigator using the M-stage DD classification system. The classification system describes various clinical stages over the course of the disease based on morphological observations between healthy, active, healing, and chronic stages. A primary library of a single hoof per image and two class labels includes 1,177 M0/M4 and 1,050 M2 images. A secondary library of multiple hooves per image and five labels consists of 240 M0, 17 M2, 51 M2P, 114 M4H, and 108 M4P labels for a total of 409 images. Faster region-based convolutional neural network (R-CNN), Cascade R-CNN, Single Shot MultiBox Detector (SSD), and SSD Lite in addition to the four latest versions of You Only Look Once (YOLO): YOLOv3, Tiny YOLOv3, YOLOv4, and Tiny YOLOv4 were all trained to detect M-stages of DD for the respective datasets. Frames per second (FPS) were used for inference time to evaluate the time to predict the bounding box and class labels of the located objects in an image. In addition, precision, recall, and mean average precision (mAP) at intersection over union (IOU) of 0.5 were used for performance measures to compare between the predictions made by the CV models and a trained investigator (ground truth).

## Results

Tiny YOLOv4 outperformed all other models with respect to inference time by a wide margin with a speed of 333 FPS. The next closest models were SSD and SSD Lite at approximately 100 FPS, followed by YOLOv4 at 65 FPS. The YOLO and R-CNN models performed well compared to the ground truth using the primary dataset of single object per image and two class labels for object detection. The YOLO and R-CNN models achieved a mAP between 0.964 to 0.998 whereas SSD and SSD Lite achieved a mAP of 0.371 and 0.387 respectively. Overall, YOLOv4 and Tiny YOLOv4 outperformed all other models with near perfect precision of 0.980, perfect recall of 1.000, and the highest mAP. YOLOv4 and Tiny YOLOv4 were evaluated for real-world

application using the secondary dataset of multiple objects per image and more class labels for object detection. Both models performed well compared to the ground truth where YOLOv4 and Tiny YOLOv4 achieved very similar mAP of 0.896 and 0.895 respectively. However, Tiny YOLOv4 achieved both higher precision of 0.870 and recall of 0.920.

### Conclusions

The YOLO models were able to detect DD lesions in a milking parlor with high performance and speed as well. Tiny YOLOv4 was the best computer vision model for the use case and implemented for real-time detection of DD in dairy cattle. Tiny YOLOv4 was able to detect all five class labels reasonably well. However, the model was able to detect M2P, M4H, and M4P much better than M2. As a proof-of-concept, we were able to detect different M-stages of DD using MP4 video and via webcam. This result is a small step in applying CV algorithms to veterinary medicine and implementing real-time detection to dairy farms. The proposed CV tool can help dairy farmers and producers improve DD prevention strategies for early intervention as well as helping increase cattle welfare and production.

# **The cleftabet – Evaluation of interdigital cleft conformation**

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## Objectives

Dynamics of bovine digital dermatitis (BDD) and variation in susceptibility (Döpfer et al., 2012; Capion et al., 2012) has been associated with multiple factors. Genetic variation (Scholey et al., 2013) and hind leg conformation has been described as possible factors related to the individual cow. Also, this observation model may explain some of the variation that we see in dairy herds as well as deviation of BDD infection rates between front and hind legs. A study of the width of the digital cleft showed that narrow interdigital clefts have a higher risk of BDD and some interdigital clefts may be wider upon weight bearing compared to lifted legs (Daniel, 2011).

The objective of this study was to evaluate agreement between observers scoring interdigital cleft conformation.

## Materials and methods

Fourteen Danish trimmers and eight Canadian trimmers participated in the study. In each country, 16 cadaver feet were lined up, numbered and each trimmer scored the interdigital cleft conformation on elevated legs twice with a few hours' interval. Before the first scoring the participants was given a short introduction to the cleftabet. The conformation of the interdigital cleft was scored as:

D – diamond shaped narrow at the top and narrow at the coronary band with a sharp-edged opening in the middle.

I - the cleft is narrow from the top to the coronary band, shaping an I.

n – the cleft has the shape of an arch, with an opening from the top and open between the coronary band of each claw.

O – the cleft forms a ring with little/no space between the coronary band of the two claws.

S – the cleft is narrow and shape like the letter S.

On weightbearing legs cleft conformation scores D, O and n becomes n, with a wide or open interdigital cleft. Interdigital clefts scoring I and S on lifted legs becomes I or A upon weightbearing, with either a narrow cleft from the top to the coronary band or a cleft that is narrow at the top and widens out in the coronary band.

Before the second session more background on the hypothesis of an association between interdigital cleft conformation and susceptibility to DD were presented to the participants.

The golden standard was defined as the scores by Victor Daniel and Nynne Capion. From the golden standard, inter-observer and intra-observer variation was calculated by weighted kappa.



## Results

The agreement was moderate with weighted  $\kappa = 0.43$ . However, the results showed that it was difficult to distinguish between D and O. When D and O categories are considered one category the agreement was substantial to almost perfect ( $\kappa = 0.54$  and  $\kappa = 0.86$ ) in Canada and Denmark, respectively.

The intra-observer agreement was almost perfect with a mean weighted  $\kappa = 0.84$  (SE 0.02) for all trimmers.

## Conclusion

This study shows that the interdigital cleft conformation can be scored with a high agreement between observers following a limited amount of training. The individual variance in cleft conformation may play a key role in susceptibility towards infectious claw lesions and effectiveness of treatment and preventive strategies. This factor will have to be included in future studies to understand the association between DD, cleft conformation, and variation between cows and leg structure. Whether hoof trimming can improve interdigital cleft conformation needs to be evaluated further.

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# **Prevalence and risk factors for corkscrew claw syndrome in Upper Midwest dairy heifers**

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## Objectives

The objective of this study was to determine the prevalence and associated risk factors for an emerging hoof lesion in growing heifers and adult dairy cattle. Corkscrew claw syndrome (CCS) is the combination of corkscrew deformities of the medial claws of both the rear and front feet in combination, occurring in heifers predominantly from growing age upward into adulthood. This contrasts with the traditional corkscrew claw seen in the lateral outer claw of older cattle. The condition can be so severe by the time that the heifer calves that the rear medial claw is the dominant weight bearing claw. The anatomical changes that result in this condition appear to be permanent and unrepairable. The pedal bones are irreversibly changed, developing bony exostoses and becoming narrower and rotated within the claw capsule.

## Materials and methods

A convenience sample of Upper Midwest dairy herds was recruited using the expertise of hoof trimmers from the Dairyland Hoofcare Institute (Baraboo, WI) who were asked to identify dairy herds that they trimmed that had a high and low prevalence of CCS. From an initial list of 83 dairy producers contacted, 43 herds agreed to be visited by 2 observers trained to score the rear medial claws for the lesion in heifers and cows. Breeding age, pregnant and prefresh heifers were surveyed, along with the high yielding mature cow group of cows. At the visit, details of a variety of environmental and management risk factors were captured and entered into a purpose-built Microsoft Access database. The data were exported into Excel and analyzed using SAS (SAS version 9.4; SAS Institute, Inc., Cary, NC). Univariate linear regression models were built for the square root transformed prevalence of CCS for breeding, pregnant and prefresh heifers using PROC MIXED, weighted by the surveyed population of heifers. Using variables of significance ( $P < 0.15$ ) for each heifer group, multivariate models were built through the process of backwards elimination of non-significant effects ( $P > 0.05$ ), with graphical evaluation of residual plots, to explain the prevalence of CCS. A final model was built in similar manner for the prevalence of CCS across all heifer groups using effects significant ( $P < 0.15$ ) from the univariate analyses from the heifer sub-groups.

## Results

The survey found an overall prevalence of CCS across herds of 16% in heifers and 33% in mature milking cows. Data from breeding, pregnant and prefresh heifers showed that prevalence increased with age, from 13% to 18% to 23% for each group respectively. Risk factors for CCS significant in the final mixed models included breeding age bedding material for all groups ( $P < 0.005$ ), number of milking cows for pregnant and all heifer groups combined ( $P < 0.05$ ) and stall width for prefresh prevalence ( $P = 0.0049$ ). Least squares mean CCS prevalence for all heifers, when recycled sand bedding was used in the breeding pen, was 45.4%, compared to 21.5% for fresh sand, 6.2% for other organic bedding and 4.3% for unbedded mats or mattresses. Larger herds and narrower prefresh stall dimensions had a positive effect on CCS prevalence.

## Conclusions

CCS is a newly recognized lesion affecting heifers in well managed freestall herds in the Upper Midwest; many of which have other common causes of lameness under control. In the surveyed herds, almost one

quarter of the heifers were affected on average, with a range in severity. Risk factors identified in this study support the hypothesis that the lesion develops early in the heifer's development, in larger herds using sand bedded freestall rearing facilities – with a significant effect from breeding age onwards. It is hypothesized that sand bedding (especially coarse recycled sand) generates hoof wear and thin soles leading to inflammation of the pedal bone of the medial claws that are then susceptible to abnormal weight bearing forces during the period of skeletal development.

# Global transcriptomic evaluation of the hoof lamina in beef cattle with altered mobility

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## Objectives

Impaired mobility of cattle arriving at packing plants gained considerable attention in the fall of 2013. In addition to a stiff gait and reluctance to move, cattle presented with increased respiratory rates and muscle tremors. In the most severe cases, animals were observed to slough one or more hooves (claw horn capsules) during transport or while in lairage. Affected animals experience significant discomfort and when hoof sloughing occurs at the packing plant animals, these animals are unable to be processed creating both an animal welfare issue as well an economic loss to the packer. It is believed that a better understanding of possible molecular causes of this condition would help feeders develop better feeding and management practices to prevent the disease. This report describes our observations from an evaluation of the transcriptome of hoof lamina, by differential expression and co-expression network approaches, to identify gene and pathways underlying the altered mobility scores of beef cattle.

## Materials and methods

The lateral claw of each hind limb of 21 animals was sectioned and the sections of the hoof wall/lamellar corium/P3 located midway between the coronary band and the sole were collected. The hoof wall and pedal bone were sharply dissected from the lamina and the lamellar sample was directed for RNA-Seq analysis. The global transcriptome was evaluated by using DESeq2 (R package) to identify differentially expressed genes (DEG) between animals with unaffected mobility (control group; N = 4; mobility score 1), and those showing any level of alteration in mobility (lameness group; N = 17; mobility score 2, 3 and 4). False discovery rate was controlled using Benjamini and Hochberg methodology (adjusted  $p < 0.1$ ). To identify groups of genes (modules) exhibiting similar changes in gene expression across different mobility score levels, a co-expression network analysis was conducted (WGNCA). Modules were labelled with color names. We identified modules that were statistically associated with mobility scores ( $P < 0.05$ ) using PROC Glimmix (SAS), accounting for gender differences. Functional enrichment analysis was performed using the Cytoscape plugin ClueGO to identify over-represented gene function or pathway ontology terms.

## Results

A total of 1793 DEG were identified between these two groups including matrix metalloproteinase proteins (*MMP2* and *MMP11*). DEGs with higher abundance in the control group were most enriched in pathways related to protein homeostasis such as proteasome, protein processing in endoplasmic reticulum, autophagy, and ubiquitin mediated proteolysis. The

enrichment of DEG with higher abundance in the lameness group were predominantly related to vascular alteration such as VEGF, thyroid signaling pathways and proteoglycans in cancer. Co-expression analysis complemented these results with the identification of modules enriched for protein homeostasis and vascular alteration. Among six modules associated with mobility score levels, three were statistically enriched for pathways.

Modules showing higher abundance in mobility 1 and lowest in mobility 3 enriched for homeostasis and stress response (blue3, green modules). Conversely, genes with the lowest abundance in mobility 1 and highest in mobility 3 were enriched for mTOR pathway genes known to act in angiogenesis via VEGF (darkviolet module). In addition to *MMP2* and *MMP11*, four other DEGs were identified as potential biomarkers for early disease prediction. *KDR*, *PLCG1*, *MAPK1* and *NOTCH1* had higher expression levels in the high mobility score animals and were enriched in key signaling pathways such as VEGF and thyroid. *PLCG1* and *NOTCH1* were also co-expressed in the darkviolet module.

### Conclusions

The differentially expressed genes and co-expression approaches identified that hoof lamina of animals with altered mobility showed decreased expression of genes partaking in pathways related to homeostasis and stress response but higher expression of those in vascular formation and remodeling. VEGF signaling may be a central pathway regulating the vascular remodeling and angiogenesis acting together with mTOR, MAPK, PI3K and thyroid hormone signaling pathways. Therefore, our finding indicates alteration in vascularity of hoof lamina which may result in endothelial dysfunction, corroborating previous knowledge in horses and dairy cattle. We suggest pathways and genes related to vascular alteration and protein homeostasis as the major differences in hoof lamina of beef cattle with altered mobility and further studies are needed to establish causality in lameness.

# **Evaluation of biomechanical strength and strain of bovine hoof lamina in elevated mobility score market weight cattle**

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## **Objective**

Impaired mobility of cattle arriving at packing plants gained considerable attention in the fall of 2013. In addition to a stiff gait and reluctance to move, cattle presented with increased respiratory rates and muscle tremors. In the most severe cases, animals were observed to slough one or more hooves (claw horn capsules) during transport or while in lairage. Affected animals experienced significant discomfort and when hoof sloughing occurred at the packing plant, these animals were unable to be processed creating both an animal welfare issue as well an economic loss to the packer. It is believed that a better understanding of possible molecular causes of this condition would help feeders develop better feeding and management practices to prevent the disease. This report describes experimental evaluation of the relationship between the mobility of market weight cattle and the biomechanical properties of the laminar corium.

## **Materials and methods**

Eighty-six market weight cattle were evaluated at a commercial slaughter facility. Mobility scores, as described by the North American Meat Institute, were assigned by trained company employees. Animals were observed and scored during antemortem exam and subsequently marked using a color code for each score. All animals with indications of disease or blindness were excluded. Following slaughter, both front hooves were collected within the packing plant and frozen for transportation to the research facility. Using a randomization chart, left or right hooves were selected and biomechanically tested using a test frame to determine the force required to remove the hoof horn from the pedal bone. The test results were compared based on ante-mortem locomotion score.

## **Results**

In biomechanical testing all specimens failed at the junction of the dermal and epidermal lamina. This indicates that the corium and basement membrane were in a healthy state at the time the animal was harvested. The strain at break was significantly different based on the mobility scores ( $p$  value = 0.0001), with higher mobility scores demonstrating more elasticity of the lamina (strain) before breaking. Peak load at break demonstrated a downward trend as mobility score increased, but did not reach the level of statistical significance. Taken together these results demonstrate that as the mobility score increases the lamina becomes more prone to stretching with minimal resistance and ultimately capable of breaking.

### Conclusions

An increased strain at break is consistent with the clinical presentation of the lamina of higher mobility score animals stretching and allowing the pedal bone to sink. The results of this study suggest that when other causes of disease or blindness are excluded there is a direct correlation of mobility score with physiologic weakening of the lamina and the potential for sinking or sloughing of the hard hoof horn. This finding is consistent with clinical reports of high mobility animals losing their hooves. Studies to date have focused on muscle-related pathology as a possible underlying issue of the observed clinical signs. The study reported here not only explains a potential cause of the hoof sloughing (the most serious of observed signs) but also the cause of impaired mobility as possibly associated with degeneration and necrosis of the dermal-epidermal junction.

# **A history of lameness and low body condition score is associated with reduced digital cushion volume, measured by magnetic resonance imaging, in dairy cattle**

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## Objectives

The current study was designed to investigate associations between animal level variables (including lameness history) and the volume of, and fat content within, the digital cushion in adult dairy cattle at cull. The null hypothesis was that the digital cushion volume within the hindfeet of dairy cows at cull was not associated with claw horn lesion (CHL) or a history of lameness during the lactating lifetime of the animal. The secondary objective of the study was to quantify the volume and fat fraction of the digital cushion in a sample of culled dairy cows.

## Materials and methods

The retrospective cohort study resulted in the scanning of 102 pairs of hindfeet, collected from adult Holstein dairy cows culled from a research herd, using a 3-Tesla, research grade MRI scanner. Volume and fat measurements were calculated for each digital cushion within each claw from a modified DIXON quant sequence. Animal level variables were constructed around the animal's lactating lifetime, with lameness scores and body condition score (BCS) collected at least fortnightly. The combined volume of digital cushion in the lateral claws was used as the outcome variable in multivariable linear models.

## Results

A substantial range in the volume of digital cushion present within the lateral claws of animals at cull (0 – 29.86 ml). The volume of digital cushion contained within the lateral claws was negatively associated with the number of lameness events or CHL recorded. Each CHL treatment was associated with a decrease of 0.89 ml in digital cushion volume in the lateral claws at slaughter ( $P > 0.001$ , 95% CI: -1.2 - -0.6 ml). Animals with an increased proportion of lameness scores recorded as sound during the lactating lifetime had a higher volume of digital cushion in the lateral claws at slaughter. Every percentage point increase in sound scores was associated with an increase of digital cushion volume in the lateral claws at slaughter of 0.08 ml ( $P = 0.02$ , 95% CI: 0.01 – 0.15 ml).

Furthermore, animals of BCS>3, culled later in lactation, or of a greater bodyweight were more likely to have a higher volume of digital cushion in the lateral claws. Animals with a higher proportion of BCS > 3 recorded across their lactating lifetime tended to have an increased volume of digital cushion at cull. For every percentage increase in the proportion of BCS > 3, an associated increase in digital cushion volume of 0.31 ml was observed ( $P = 0.06$ , 95% CI: -0.02 – 0.65 ml).

## Conclusions

The volume of digital cushion in the lateral claws of the hind limbs varies substantially between adult dairy cattle. A large proportion of the observed variation appears associated with the



lameness history of the animal. We propose that the observations made in the current study are the effects of a range of factors broadly associated with genetic, developmental and disease related inputs. Our understanding of how we can select for genetically more robust animals and how we can pre-condition the hoof before first calving need to be improved to reduce the risk of future CHLs in adult dairy cattle. Furthermore, understanding optimal treatment regimens and their impact on hoof anatomy may reduce the recurrence of CHLs in the current lactation and future lactations

# **Large melanoma mass in the forelimb of a dairy animal**

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## **Objectives**

A Friesian dairy cow developed an aggressive mass in the distal part of the left forelimb, which finally led to the death of the animal. The animal was permanently housed in an intensive dairy farm located in the province of Zaragoza, Spain.

The animal was born on 20 March 2018. The cow's development was normal during its breeding and rearing period. The animal gave birth for the first time in May 2020, at 26 months of age. The second calving was April 2021. The cow's average milk production was 39 liters per day. The animal had not suffered any disorder or condition throughout its life so far.

However, in July 2021, the dairy cow began to develop a rapidly growing, strange-looking mass on the left forelimb, close to the hoof. Since then, the animal presented a slight lameness that grew in intensity as the mass also developed. . Initially, an elastic band was placed at the insertion of the mass to cut off blood flow and necrotise the lesion. However, it was not effective. At the slightest contact of the mass with any object, bleeding occurred. The animal progressively worsened and even suffered an abortion.

Due to these reasons, a lameness specialist thoroughly examined the mass, and after consultation with other company veterinarians, it was decided to remove the mass. A surgical solution was proposed to remove the mass, which measured more than 20 cm at this moment.

The surgery was planned for the last week of January 2022 after trying to reduce its size with a conservative treatment based on elastic bands. However, the cow suffered an accident in the previous days. For this reason, the animal was humanely sacrificed at that time without the possibility of performing the surgery.

To know the cause and origin of this mass, it was decided by the practitioners to send the left forelimb to the Clinical Ruminant Service of the Faculty of Veterinary of the University of Zaragoza to perform an exhaustive post-mortem study.

## **Materials and methods**

Hoof health was recorded using the program Hoof Manager. A post-mortem Computed Tomography (CT) exam was performed to obtain a global image of the lesion using 2-slice CT scanner (BRIVO CT 385, General Electric Healthcare). It was sought to know the macroscopic appearance of the lesion and where it was rooted. Subsequently, a post-mortem examination was performed. The exam was complemented with the collection of histological samples and the subsequent microscopic examination.

## Results

A dense cellular-like mass with a broad stalk attached to the distal part of the forelimb, above the accessory phalanx, was observed in the Computed Tomography (CT) exam.

A uniform blackish colouration, both externally and in section, was observed in the post- mortem macroscopical study. The black cellular tissue was infiltrated by white lines with a dense fibrous appearance when the mass was sectioned. In the insertion area, it was appreciated that the mass grew in the latero-lateral part of the forelimb, originating in the skin.

Microscopically, the lesion is described as a highly cellular, non-circumscribed, unencapsulated and moderately pigmented nodular mass, occupying the superficial and deep dermis. It is composed by sheets of 28-35  $\mu\text{m}$ , well-demarcated polygonal to stellate well differentiated melanocytes with variably granular dark pigmented cytoplasm and a round to ovoid nucleus with punctate chromatin and 1-2 prominent nucleoli. These cells are disposed on a moderated to abundant collagenous and edematous dermal stroma, admixed with multiple adipocytes.

The mass embedded some follicular adnexa with an infiltrative growth and showed high neovascularization. Melanocytes often surrounds neovessels forming perivascular cuffs.

Based on these findings, the mass was diagnosed as melanoma.

## Conclusions

Melanoma is a skin neoplasm that has its origin in melanocytes. It is not a very common problem in cattle; however, they are sometimes observed. Most of them are defined as benign. But on occasion, they grow to massive sizes or metastasise in other locations.

In this case, no metastases were detected, but due to its large size, it had severe and direct repercussions on the health of the affected animal.

## **Lameness as a problem on sanctuaries – A case study**

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### Objective

The keeping of cattle on so-called sanctuary farms is increasing in Germany. Dairy cows are "rescued" from slaughter, male calves are bought by animal welfare organizations, animal rights activists and private persons and are passed on to sanctuaries before being sold to fatteners. These males are castrated to prevent alleged aggressive behavior towards humans, but of course also to prevent mating. Often this is done very early at an age of a few months. As a result, these steers grow slower than uncastrated bulls, become very long-legged and sometimes very heavy. Often, these animals are treated like companion animals. Against this background, the question arises whether the housing conditions on these sanctuaries meet the needs of the animals, whether the care - including hoof care - is always appropriate and if adequate action can be taken in the event of disease. The following case study is presenting an example showing why these questions have high practical relevance and what measures can be taken, if the owner is willing to invest.

### Material and methods

On a sanctuary in Germany, a group of 10 cattle is kept in a compound with an approximately 100 sqm L-shaped shelter open on one side. The muddy 800 sqm run was renovated - inadequately - 1 year before the study took place. It is covered with a 20 cm thick layer of sand and the underlying drainage layer is not functioning. As soon as it rains, large puddles and muddy areas form, which freeze over into ice-slick surfaces in winter times. Under these conditions, an approximately 1400 kg steer with a shoulder height of about 2 m probably slipped at night and was found by staff the next day highly lame. An initial veterinary examination revealed high-grade swelling of the right knee, which was highly painful, and cracking sounds were perceptible when it was in motion. Under immediate pain therapy with meloxicam (0,5 mg/kg s.c.), the gait improves from LS 5 to LS 4 and the animal was reintegrated into the herd. To rule out damage to claws and other joints, the animal was examined in a suitable tilt table. A comparative ultrasound examination of both knees showed a strong filling of the right knee with echo-poor fluid, floating parts of the lateral meniscus and the collateral ligament in it. Based on these findings and the weight and size of the animal, the prognosis was considered unfavorable. Nevertheless, it was the owner's desire to continue to maintain this exceptionally friendly animal if pain control was possible. Under permanent medication with meloxicam, the so-called orthokine treatment of the knee was performed after 4 weeks. A blood sample of 100 ml was taken from the patient into commercially available serum vacutainer (Orthokine vet syringe). After 12 hours of incubation at 36 °C blood cells are supposed to be stimulated to produce protective proteins that hold anti-inflammatory and regenerative properties. After puncture of the knee about 150 ml of serous fluid was drained. Then, using a sterile filter as a syringe attachment, 10 ml of prepared serum was applied intraarticularly. This was repeated after 3 weeks.

## Results

Under continued oral meloxicam (0,5 mg/kg every 48 hours) and two local inoculation therapies with stimulated serum osteoarthritis initially did not deteriorate - in the beginning even without additional clinical changes. Unfortunately, the attention of the caring staff waned after 5 months, so deterioration of the condition was initially overlooked. The animal developed claw ulcers on the three healthy limbs due to overuse. Veterinarian consultation was requested too late. Because of the very unfavorable prognosis, the animal was ultimately euthanized.

## Conclusion

In principle, the keeping of prematurely castrated male cattle places special demands on the owners, especially with regard to space and care requirements. In particular, slippery running surfaces are always associated with the risk of falls, which can lead to serious injuries due to their size and weight. In principle, the use of anti-inflammatory measures - systemically administered NSAIDs and locally so-called autologous protective proteins - can temporarily lead to a reduction in pain in a traumatic knee injury. However, this again is only symptomatic but no causal treatment and not a long-term solution due to the size and weight of the animal. Therefore, both husbandry and medical care of these animals need special attention in terms of animal welfare.

# **Case report about the treatment of a pedal bone fracture in a Holstein Frisian heifer**

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## Objective

The heifers are the future on every farm. On a lot of farms, poor housing conditions of heifers contrast with the needs of the young animals and their potential (1,2). The flooring must fit the needs of the animal. Especially gap expanses of slatted floors need to be smaller than the hoof width of the housed animals (3). Pedal bone fractures due to hooves getting stuck in slatted floors with too wide gaps is a known problem of poor housing and often comes along with a partial disruption of the horn capsule from the corium (4). This is a study about a young heifer with a pedal bone fracture due to inappropriate flooring.

## Material and methods

On a breeding farm a genetically high testing and valuable female heifer (9 months) was suddenly severely lame and presented to the veterinarian. The affected foot was X-rayed. Due to the finding of a fracture of the pedal bone the hoof was immobilized with synthetic casting tapes and a block was fit to the sound inner hoof. Because it was a covered fracture, the additional value for the animal of having both hooves as a heavy, grown-up cow and the owner's intention to raise her as a show cow, the treatment plan aimed to preserve the damaged hoof.

## Results

The immediate X-ray examination after the heifer was found severely lame showed a transverse fracture line through the pedal bone of the right hind outer hoof. At the beginning of the treatment, on the one hand, it seemed as if the horn capsule of the affected hoof wasn't disrupted from the corium. With the synthetic casting tape, the heifer showed full weight bearing on the affected limb. On the other hand, the displacement of the axis through the distal interphalangeal joint and the severe tenderness of the torus region suggested a dislocation of the joint in addition to the diagnosed pedal bone fracture. 20 days after the heifer was identified severely lame the axial coronary band was loose and it was possible to underrun the horn with a probe over the full length. 41 days after the treatment started an axial horn fissure and ulcer had formed underneath the horn capsule. A second X-ray examination on that day revealed that the fracture line in the pedal bone showed callus formation after the 7 weeks of walking with a cast and a block but also a sequestrum was identified. Because of the protracted healing perspective of the distal interphalangeal joint with an open outcome in combination with the low compliance of the personnel, the damaged hoof was amputated to reduce suffering for the animal. The amputated hoof is already scheduled for a Magnetic Resonance Imaging (MRI) scan to evaluate the damage of the distal interphalangeal joint and the ligaments.

## Conclusion

Generally, synthetic casting tapes are a good and economically interesting tool to take care of fractures in the pedal bone of a young heifer, where bone fractures are likely to heal well due to a

lower live weight and the ongoing growth. It is possible to splint the fracture to enable the essential callus formation and preserve the damaged hoof. But this case showed impressively that the treatment only makes sense when there isn't a displacement of the distal interphalangeal joint or a sequestrum underneath the corium. An immediate amputation of the damaged hoof would have shortened the follow up care considerably.

When keeping young heifers especially in heat on slatted floor, it is even more important to make sure, that the hoof width is at least a few millimeters wider than the gaps in the slatted floor. While jumping on other heifers' backs the tip of the toes are more likely to slide into the gaps of the slatted floor and get trapped. The following movement of the animal can lead to severe damage on the hooves and cause immense economic loss due to high costs for veterinary treatment, time consuming follow up care and delayed first insemination rate or even total loss of a valuable heifer.

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# Survey of foot lesions found at foot trimming of dairy goats

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## Objective

There have been few reports of hoof lesions in housed adult dairy goats, most of which have been in lame goats in herds with a lameness problem. As far as the authors are aware there has been only one peer-reviewed published population-based study of hoof lesions in dairy goats which was published in 1999. We need more information on foot lesions in housed dairy goats, especially in goats that are not lame. Routine hoof trimming of all or a large proportion of the goats is common method n dairy goats and provides an opportunity to assess foot lesions in goats. The aim of this study was to classify and evaluate, on two occasions on four dairy goat farms in the Taranaki region of New Zealand, the foot lesions observed during routine foot trimming.

## Materials and methods

The survey was undertaken on a convenience selection of farms on which all milking goats. All data were collected from milking goats at the time of routine herd foot trimming. Data were collected from all four farms between 15 January 2019 – 14 February 2019, and then again ~15 weeks later on three farms only. During foot trimming, all four feet were examined, and the lesions observed were recorded. Lesion data were collected in three categories: i) separation (site, i.e., toe, white line, axial, sole or heel, recorded), ii) granulation (site recorded), and iii) Infection-related (scald, footrot or secondarily infected lesion. All lesions were recorded so one goat could have multiple feet with lesions and multiple lesions within the same feet.

## Results

Across all farms on both occasions the number of trim records was 3,850. No lesions were observed on any foot on 1,328/3,850 (34.5%). At least one separation lesion was observed in 2,126/3,850 records (55.2%). The equivalent figure for at least one granulation lesion was 706/3,850 (18.3%). Lesions with secondary infection were observed on 471/3,850 (12.2%) occasions No goats were recorded as having footrot and only 20 as having scald.

White line separation was the most commonly recorded lesion with 1,599 of the 3,850 (41.5%) records coming from goats which had at least one white line separation lesion. The second most common recorded separation was separation of sole horn at the toe which was recorded 303 times (7.9%). Toe separation was much more commonly associated with toe granuloma than white line separation was with white line granuloma. Of the 303 records which had a toe separation lesion, 277 also had a toe granuloma (91.5%); in contrast only 169 of the 1,599 records of white line separation had a white line granuloma (10.6%). A toe separation was more than 8 times as likely to be accompanied by a toe granuloma than a white line separation was to be accompanied by a white line granuloma (relative risk (RR) = 8.6 (95%CI 7.5 to 10.0)). The situation was similar for heel and sole granulomas where 82% and 88% of separations, respectively, also had granulation tissue.



## Conclusions

Non-infectious disease was the predominant lesion type in this study with contagious hoof disease being very rare, despite footrot being common in sheep and goat at pasture in New Zealand and commonly found in housed goats elsewhere. Clearly, we need further research on the prevalence and impact of footrot in housed dairy goats in New Zealand and elsewhere.

We need agreement on definitions of non-infectious lesions. We defined lesion by site of origin and type. We believe that this is likely to prove useful in understanding the pathogenesis of hoof horn lesions in goats, but the repeatability of our system needs testing on more farms with more observers. This should be accompanied by longitudinal studies into the pathogenesis of hoof horn lesions in goats. This research should look at the relationship between granulomas and separation, which our research suggests vary, depending on the site of horn separation and on how the prevalence of lesions changes with time and the factors affecting that change.

## **Actual lameness scores: Do more categories = Better data?**

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### Objective

Locomotion scoring is commonly used to score gait, but there is limited agreement as to what systems are best or how valuable actual scores are. Unlike in cattle, there are no well-developed, well-established gait scoring systems in goats. One recent paper suggested that the lack of a category for uneven gait was a failing in most goat locomotion score systems (creating a 5-point system from a four point-system with three categories for lame goats). The aim of this paper is to use data from locomotion scoring on 4 commercial goat farms to assess whether this conclusion is correct and to reflect on the importance of using actual scores rather than simple lame/not lame dichotomies.

### Materials and methods

We adapted a four-point scoring system used for cattle (AHDB/DairyNZ lameness score), which has two categories for lame cows and also a category for imperfect gait. Locomotion scoring was then attempted on four dairy goat farms. Goats on each farm were scored walking back to their pens after milking, with the observer being positioned in a vehicle approximately 10 metres away from the walking goats to reduce distraction. This ensured that the maximum number of goats were scored on each occasion and that they were all scored walking on a hard surface.

### Results

Locomotion scoring proved feasible on only three-fourths of the farms. On the fourth farm, the distance from the parlour to the pen was too short. Over the two occasions on each of the three farms, 80% of goats had normal gait, with 13% being lame but still weightbearing. Imperfect gait without lameness was rare (4% of scores) as was lameness without weightbearing or lameness with a clear effect on walking speed (3%). The locomotion scoring system proved, as in cows, to be an achievable method of scoring large numbers of animals.

### Conclusions

These results highlight the question of whether the actual scores in a locomotion system are useful in a farm context (and even in a research context). The top score we used was equivalent to the top two scores in the 5-point system (and the 4-point system it was adapted from). From a practical perspective, lame goats that are reluctant to move forward or weight bear should be treated immediately the same as goats that are unwilling or unable to do so. Distinguishing between them has little relevance to farm staff. From a research perspective, these top scores are very rare – no goats scored 5 in the study of the 5-point system and only 3% scored the top score in the original study that developed the 4-point system they extended, so there may be little to lose by encompassing top scores in a broader severely lame category. The same applies in cattle too, where the top score in the most commonly used 5-point system (an inability or extreme reluctance to bear weight on one or more of limbs/feet) is very rarely recorded. It's not just an absent score that is the issue – comparisons of scoring systems often equates the top score of a 5-

point system with that of a 4-point system, even when it is clear from their descriptors that the top score of a 4-point is (broadly) equivalent to the top two scores of a 5-point system.

Regarding imperfect gait, it was suggested that including this category could result in earlier on-farm lameness detection. The same definitely does not occur in cattle (where some systems just tally imperfect gait rather than record the identity of the infected cow) and our results suggest that, in goats, imperfect gait is much rarer than in cows. This is in direct disagreement with the original 5-point study, which suggested that the number of goats with normal and imperfect gait was equivalent. However, that was based on individually observing goats, rather than observing in a group, which is the only way that large numbers of goats will be examinable. So, either imperfect gait in goats reflects incipient lameness, but is almost impossible to detect on farm, or observing individual goats identifies quirks in goat gait, which are not of clinical importance and will not be detected when goats walk in a group.

# **Antibiotic-free treatment of foot lesions in dairy goats**

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## **Objectives**

Lameness in dairy goats is not as highly researched as in dairy cows or sheep, so information is often extrapolated from other species. Certain parallels can be drawn but there are differences in housing system, nutrition and foot anatomy (Groenevelt, 2017). Data that is published shows a big impact on welfare and production, including a decreased milk production (Christodouloupoulos et al., 2009). High within farm prevalence's, up to 67%, have been reported (Groenevelt et al., 2015; Sullivan et al., 2015).

As effective treatment alternatives are lacking, antibiotics are still commonly used for individual treatment. Chelated copper and zinc are proven alternatives for antibiotic spray in the treatment of Digital Dermatitis in dairy cows (Holzhauer et al., 2011; Dotinga et al., 2017). The goal of this study is to investigate whether a non-antibiotic spray results in comparable cure than antibiotic spray for foot lesions in dairy goats.

## **Materials and methods**

This non-inferiority trial was performed at the Dutch goat innovation centre (GIJS Mekkerhof BV). The non-antibiotic spray containing copper and zinc chelates (Intra Epidine) is referred to as IE. The positive control was antibiotic spray (Engemycine Spray) and is referred to as OTC. Lame goats were selected, trimmed and scored according to the scoring system as developed by Stewart and Claxton (1993) for footrot in sheep, which divides lesions into scores 0 (healthy foot) to 5 (most severe stage). Lame goats who were scored as 0 were not included in the trial.

Every hoof with a score 1 to 5 was photographed after trimming and allocated to a treatment group. In both treatment groups, on day 0 scores 1 and 2 (mild lesions) were treated without bandage, scores 3, 4 and 5 (severe lesions) were treated with a gauze and a bandage. Each lesion score received alternating treatment with IE or OTC. In total, this led to 46 feet in the IE group and 46 feet in the OTC group. On day 7 the lesions were scored again. Cure was defined as a score 0 on day 7 for mild lesions, or as the absence of infection for severe lesions. Statistical analysis was performed using the Fisher's exact test to analyse if there were significant differences in cure between treatment groups. A p value <0.05 was considered as statistically significant.

## **Results**

In total the trial included 92 lesions from 43 goats, of which 30.4% were classified as mild lesions and 69.6% were classified as severe lesions. Of the 43 goats, 69.8% was affected by more than 1 lesion. The division of lesions over the total of 4 legs was rather equal as all legs had 20-30% lesions.

Seven days after treatment, 80.4% of the lesions healed with IE and 73.9% of the lesions healed with OTC, with a relative risk of 1.22. There were no significant differences.

### Conclusions

There were no significant differences between the curative effect of copper and zinc chelates and antibiotic spray on foot lesions in dairy goats. Therefore, IE could be used as an antibiotic free alternative and incorporated in daily practice.

# **Environmental transmission of *Treponema*-associated hoof disease in captive elk**

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## Objectives

Treponeme-associated hoof disease (TAHD) is an emerging disease identified in free-ranging elk (*Cervus elaphus*) in the northwestern U.S. Although *Treponema* spp. are associated with lesions, the definitive etiology has not been determined and transmission has not been confirmed. Our objective was to determine whether TAHD was transmissible to healthy captive elk through soil contaminated with hooves from affected elk.

## Materials and methods

Six captive elk were housed in individual concrete-lined stalls at a research facility at Washington State University (WSU), Pullman, with oversight and approval from the WSU Institutional Animal Care and Use Committee. Between October 2020 and March 2021, four treatment elk were exposed to an inoculum prepared with hoof homogenate from TAHD positive elk and mixed with soil. An aliquot of the inoculum was applied to an abraded interdigital space (IDS) and held in place temporarily with a light foot wrap. Additionally, inoculum was mixed with pen soil. Two control elk were challenged identically except with inoculum prepared using TAHD-negative hooves. Over the study period, eight challenges were conducted at 2- to 4-week intervals. Daily lameness scoring was conducted and marked lameness was mitigated with an oral non-steroidal anti-inflammatory drug. At each challenge, hooves were examined for the development of gross lesions, and IDS scrapings were collected for 16S amplicon sequencing of DNA. IDS biopsies were collected at the end of the experiment for histologic examination and 16S amplicon sequencing of DNA.

## Results

All four treatment elk developed gross and histologic lesions consistent with TAHD whereas the control elk did not develop lesions. Persistent TAHD lesions were observed in all treatment elk by 4 months and progressed to severe lesions by 5.5 months post-study initiation. Three treatment elk were euthanized when they met humane endpoints, while one recovered. *Treponema* spp. were detected in IDS scraping and biopsies from all treatment elk but not from control elk. Other bacterial families associated with TAHD in free-ranging elk were also overrepresented in treatment elk.

## Conclusions

Our results provide evidence that TAHD is a transmissible infectious disease. Severe lesions indistinguishable from those in free-ranging elk occurred within 5.5 months following first exposure to soil contaminated with TAHD positive hooves.

# **Exploring farmer and advisor lameness management behaviours using the COM-B model**

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## **Objectives**

Lameness in sheep and cattle is one of the top endemic health conditions, both in the UK and further afield. Previous research has highlighted improved knowledge of best practice in relation to lameness management and treatment, yet there are several barriers to on-farm implementation of this body of knowledge. This includes in relation to farmers' and advisors' behaviour, and their interactions in managing and responding to lameness. Existing research has sought to apply behaviour change theory to on-farm management practices. One such framework is the Behavioural Change Wheel (BCW), which focuses around the COM-B model of behaviour, and seeks to explore the role of capability, opportunity and motivation in a given behaviour. This research uses this model to explore: 1) farmer and advisor perceptions of lameness in sheep, beef and dairy cattle systems; 2) how capability, opportunity and motivation influence lameness management practices in these systems, and; 3) how interaction between farmers and their advisors influences lameness management in these systems.

## **Materials and methods**

Ethical approval for the research was obtained from both research institutions prior to data being collected and all participants provided consent to take part. A qualitative approach was undertaken, specifically semi-structured interviews with farmers and their advisors. All farmer participants kept one or more of dairy cattle, beef cattle and/or sheep and were based in the north of England (UK). Their advisors were based in the north of England or operated at a national level. In total 29 farmers and 21 advisors took part. Interviews took place in person (n=13) prior to the Covid-19 pandemic, and either online or over the phone (n=37) after Covid-19 restrictions were imposed.

All interviews were recorded, transcribed and uploaded into Nvivo for thematic analysis. Identified themes were then explored in relation to the COM-B model to identify the role of capability, opportunity and motivation in lameness management.

## **Results**

Lameness was viewed as complex and multifactorial across beef, dairy and sheep sectors. Whilst knowledge surrounding lameness would appear to be good, as demonstrated through various management techniques, several challenges to the application of this knowledge and implementation of best practice were identified in relation to both physical and social opportunity, psychological capability and motivation, and the interaction between these. Factors related to social capability included farmers' perceived habituation, industry targets or requirements for lameness prevalence (i.e., assurance schemes) and the need for good farmer-advisor relationships, in particular with vets. Whilst a social pressure comes from within each livestock sector to have low levels of lameness, these can be challenging to deliver. The physical

opportunity for lameness management was limited in some instances by practical constraints on farm, including time, finance and environment considerations, including several perceived to be outside of the farmer's control. Physical opportunity was also limited for advisors in terms of practical opportunities to engage on-farm reducing opportunities for conversation.

In addition, advisors in particular perceived that there was also a culture of being habituated to lameness, especially within the sheep sector, with perceived levels of lameness often lower than the actual prevalence. This coupled with the perceived inevitability of animals becoming lame by farmers, the condition's chronic nature and emotiveness (no one likes to be seen to be cruel) also influenced farmers' psychological capability and motivation for management.

Central to addressing the above was a need for good farmer-advisor relationships. Within this, the communication and interpersonal skills of advisors were viewed as important facilitators for building good relationships and creating opportunities for managing farmer motivation and beliefs surrounding their capability within individual contexts.

### Conclusions

This research highlights the importance of physical and social opportunity, psychological capability and motivation for farmers in the management of lameness. In particular, the acknowledgement of the importance of developing good farmer-advisor relationships is significant. These findings would suggest that strategies that facilitate enablement of farmers (e.g., reducing barriers to increase capability) would be important for improving lameness management, with advisors playing a key role in supporting farmers in achieving this. Given that vets in particular would appear to have an important role in enabling farmers to change, future strategies should therefore look to maximise opportunities for engagement between them.



# **Survey of DD prevalence on cattle auctions – The risk of introducing DD on a farm by buying external livestock**

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## Objective

Digital dermatitis, caused by an infection with treponemes, is a common cause of economic losses on dairy farms. Acute lesions (DD-M2) can cause lameness and is also an animal welfare issue.

Diagnosing early stages (DD-M1, small DD-M2), it is possible to improve the therapeutical outcome. To detect early stages of DD evaluation of hoof health should be performed regularly – e.g., by a foot check during milking in the parlor. The key for dairy herds to keep DD out is a closed herd management without any purchase of cattle. Farms already affected by DD avoid bringing super spreaders into their herd.

On livestock auctions the risk to buy infected animals can be estimated by the percentage of affected farms (DD affects 70 to 90% of U.S. dairies similar to German farms), that is why, a Southern German breeding association decided to screen every animal's feet for DD which is presented on the monthly auctions they host (mainly first lactating cows, few heifers, few multi-lactating cows).

## Material and methods

Every animal was screened for acute (DD-M2) and chronic (DD-M4) stages before entering the auction hall. All sellers had been informed about this protocol. Visible acute stages (M2) led to exclusion of the animals from the auction, chronic lesions were documented with this information being available to sellers/bidders.

From 02-2018 to 02-2020 12 auctions took place with an average of 125 dairy cows (67-148; 1503 in total). In the morning before the auction cows passed a parlor to enter the lobby of the auction hall. All feet were cleaned with warm water from a hose and then scored while standing using a flashlight and telescope mirror. Visible digital dermatitis lesions were scored according to M-stages by a well-trained veterinarian. M0 was documented when no signs of any DD-lesion were observable, however, without accessing the interdigital cleft. When an M2 lesion was observed, a photo was taken of the feet and ear tags additionally.

## Results

5,5 % of the examined cows had minimum one foot with a DD-M2 lesion. On the level of the auctions this number fluctuated between 2 % to 7,3 % (M2). M4-stages showed a higher incidence: 42,7 % animals showed no M2, but M4 on at least one foot. Cows with M2-lesions on at least one foot often had also M4-lesions on one or more other feet. 50,4 % of the cows had M0 (as defined) on all feet, there were only a few individuals with clear M1 or M3 lesions. Initially, during the first three auctions, there was some discussion with sellers about the diagnoses, which

could be sorted out immediately. There was a noticeable change of attitude in the sellers. The diagnostic protocol was accepted and treatments of former acute lesions could be observed. Nevertheless, there was not one single market without acutely affected animals.

### Conclusion

DD is an enormously widespread disease. Acute and chronic lesions can be detected easily in a parlor by well-trained persons. Management of DD must include external biosecurity - no acutely affected animal should enter a farm, chronically affected cows need special care to avoid relapses. Bidders on dairy cattle auctions should be safe from buying cattle with acute DD-lesions (M2, M4.1). Screening for DD-lesions before auction could be one method to manage this. Recording on auctions showed that considerable numbers of animals can be diagnosed with M2-lesions despite all sellers being informed about protocols. For comparable dairy farms, a clear recommendation is: Keep farms closed. Only increase your dairy herd with your own youngstock. Do not bring in one single animal.

# **Randomized clinical trial investigating the impact of exercise and standing on concrete for five weeks prior to first calving on time to first lameness event in dairy heifers**

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## Objectives

Recent international research has demonstrated that one of the more important risk factors for lameness is a previous case of lameness. This suggests that an increased amount of effort should be aimed at extending the time to first lameness case, with particular emphasis around the transition period for the heifer. The transition period for heifers is relatively unique in New Zealand, in that a large proportion (>80%) of dairy heifers calve over a short time frame of approximately 2 months, and these heifers have usually spent the majority, if not all, of their life prior to first-calving event on pasture. Yet after calving, these animals are exposed to a host of new environmental and management stressors, and to the now well-accepted consequences that calving has on the hoof.

The primary objective of this study was to assess whether a conditioning and exercise regime 5 weeks pre-calving increases the time to first lameness event in dairy heifers in pasture-based systems. Practically, this objective investigated whether we can alter pre-calving transition management in first-calving heifers to make them more able to withstand the physiological and management changes that occur post calving with respect to hoof health.

## Methods

This study was conducted on a convenience sample of six spring-calving dairy farms in the North Island of New Zealand.

All dairy heifers present on the enrolled study farms at the study start date (approximately 5-6 weeks prior to the start of calving for each herd) were enrolled into a randomised clinical interventional trial and randomly allocated into intervention or control group at a ratio of 1:1 on each farm. The heifers in the intervention group walked from the paddock that they have been allocated to by the farmer, along the farm race (~0.5-1.0 km one way) to the concrete collecting yard where they stood on concrete for approximately one hour. They were then walked back to their grazing paddock. The intervention took place five days a week for five weeks (i.e., 25 intervention days across 35 days). Control animals were managed as per normal farm practices on pasture prior to calving. At the completion of the intervention phase, just prior to the planned start of calving for the heifers, the two treatment groups were joined together in preparation for calving. All study animals were followed for up to 210 days.

Fortnightly Lameness Scoring (LS) data were collected by one of two trained technicians, starting two weeks after the first heifer in each herd had calved, and continued for 15 LS events (LS 0-3). Farmers were also instructed to record the animal number and date of all cases of lameness that they diagnosed on farm. These farmer-recorded lameness cases were analysed as

lame, regardless of their LS status. The outcome was analysed as time-to-first lameness event, with survival analysis techniques utilised.

### Results

There were 392 heifers in the treatment groups and 390 heifers in the control groups enrolled. A total of 102/782 (13.0%; 95% CI 10.9-15.6%) heifers were diagnosed as lame; 51 of these were diagnosed during LS events, and the other 51 were diagnosed by farmers.

Fifty-three of the lame animals belonged to heifers in the treatment group, and 49 in the control group. There was no difference in the hazards of lameness between treatment groups; the hazard for a case of lameness in the treatment group was 1.12 times (95% CI 0.65-1.95) the hazard of a case of lameness in the control group.

### Conclusion

Despite the study involving a large number of heifers, the true lameness risk was lower than expected. This reduced the power of our study to find small differences between the treatment groups. However, it does need to be concluded that it will be unlikely that this current intervention will reduce lameness rates to any biologically important extent in first lactation dairy heifers, and that we urgently require other practical science-based methods to reduce the incidence of lameness in dairy cows.

# Prediction of lameness in dairy heifers using untargeted metabolomics

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## Objectives

This study aimed to investigate the use of untargeted metabolomics (liquid chromatography-mass spectrometry (LC-MS)) to differentiate the metabolome of lame and non-lame first lactation dairy cows and evaluate the predictive accuracy of identified metabolites. Study objectives included 1) evaluating the predictive accuracy of the metabolome from urine collected at the time of lameness and 2) evaluate the predictive accuracy of the metabolome from urine collected during the transition period. If successful, these techniques could be utilised to develop tools for the early prediction of lameness as part of preventive strategies.

## Materials and methods

Urine samples were collected from two separate cohorts of dairy heifers housed at a 300-cow research dairy herd; cohort 1 were current first lactation cows and cohort 2 were heifers recruited pre-calving (3 weeks) and monitored until 70 days in milk (DIM). Mobility scores were recorded weekly with lameness defined as two consecutive weeks  $\geq 2$  [0 – 3 scale (AHDB)]. Urine samples were collected from lame and match paired by DIM non-lame heifers and snap frozen in liquid nitrogen prior to storage at -80 C. For cohort 2, samples were collected pre- and post-calving (within 3 weeks) prospectively with samples being selected once the lameness outcomes were known. Samples were analysed using untargeted LC-MS (Q-Exactive Plus mass spectrometer equipped with Dionex U3000 UHPLC system) to generate semi-quantitative metabolomic data, which were analysed using a suite of machine learning methods to identify the models with the best performance in terms of prediction accuracy.

## Results

Cohort 1 included a total of 90 heifers (45 lame and 45 non-lame). Cohort 2 included a total of 30 heifers (15 lame and 15 non-lame). The best performing machine learning model for samples collected at the time of lameness predicted lameness with an accuracy of 82%. For samples collected pre-calving the predictive accuracy was 73% and for samples collected post-calving the prediction accuracy of the best performing model was 75%.

## Conclusions

This study demonstrated that untargeted metabolomics could be used to differentiate lame and non-lame heifers and that the metabolome can be used to predict lameness with an accuracy of between 73 to 82%. Furthermore, the differences in the metabolome between lame and non-lame first lactation cows were apparent as early as within 3 weeks pre-calving, which suggests development of tools utilising these techniques could offer huge opportunities for the early identification of high-risk cows that could aid lameness prevention strategies.

### References

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# **One health perspective on formalin footbaths**

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## Objective

To investigate occupational formaldehyde exposure levels of Dutch dairy farm workers due to formalin footbaths, and to study if this exposure falls within established safety norms.

## Material and methods

Stationary active air sampling was conducted on 20 dairy farms to determine air formaldehyde concentrations next to the footbath and in the milking parlor during the time the footbath was used. Furthermore, temperature, relative air humidity, CO<sub>2</sub> and air pressure during measurements were collected using a climate monitor, to assess if meteorological conditions influence air formaldehyde concentrations. Potential exposure routes, exposure time, expected formalin footbath concentrations and possible confounders were determined through a structured interview. Footbath formaldehyde concentrations were measured to assess possible association with formaldehyde concentrations in the air.

## Results

Footbath use lasted between 1.0-1.5 hour. Air concentrations of formaldehyde next to the footbath ranged from < limit of detection to 0.316 ppm, with seven measurements exceeding the long-term 8-hour time-weighted average occupational exposure limit (OEL). No concentration exceeded the short-term 15-minute time-weighted average OEL. Formaldehyde concentrations were generally lower in the milking parlor. Nonetheless, on two farms formaldehyde concentrations exceeded the 8-hour OEL in the milking parlor. In general, footbath formaldehyde concentrations remained more or less the same when measured before and after cow passages.

No strong associations between formaldehyde concentrations in the air and footbath concentrations, evaporation surface of the footbath, climate conditions, sampling height or distance from the footbath were observed.

## Conclusion

Based on time activity and observed formaldehyde air concentrations, the exposure of Dutch dairy farm workers presumably falls within the established safety norms. Nonetheless, substantial levels of formaldehyde could be detected on farms. Hence, this study further emphasizes the importance of substitution of formalin and the need to inform dairy farm workers on exposure risks.

# Online training tool for the M-score of bovine digital dermatitis lesions

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## Objective

Enable independent training to classify lesions of digital dermatitis using the M-score.

## Material and methods

A pre-selection of digital photographs from lifted hind feet were scored by a computer vision and artificial intelligence system and three experts (one academic, one private consultant, and one foot trimmer). Only photographs for which 3 scorers agreed were retained for the training tool.

The online training tool consists of:

- A decision tree detailing the steps needed to go through to end up with a final M-score for a lesion, including short video clips, explain each step and M-score.
- The decision tree has been presented during the post-congress workshop of the Lameness in Ruminants Congress 2019, Tokyo, Japan.
- A set of training photographs that can be scored with the provision of instant feedback on the score.

To track progress, users will be asked to score a pre-defined set of photographs when entering the learning environment. The same, shuffled, set of photographs will be presented to the users after completion of the training. Users who complete the training, expected to take 30 to 60 minutes depending on the level of experience and scoring speed, and both start and end evaluation receive feedback on their progress.

Users will be asked to provide information on their profession, years of experience using the M-score, employment, gender, and age. Anonymous use of the learning environment is possible. After obtaining consent from the users, data collected from before the training will be compared to after the training in order to quantify the effect of the training tool in recording M-scores of digital dermatitis.

## Results

Not applicable.

## Conclusion

This online tool will be freely available and helps to improve correct M-score classification of digital dermatitis lesions in cattle.



# **An observational study on managing digital dermatitis through risk assessment and veterinary advice on 19 Dutch dairy herds**

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## Objectives

First, identify associations between digital dermatitis (DD) prevalence and a DD risk score. Second, determine the effect of veterinary advice based on the risk score on DD prevalence and management by farmers and their veterinarians.

## Material and methods

Nineteen farms with routine veterinary herd health visits from one veterinary practice were visited between March and April in 2016 and 2018. Selection criteria were (1) presence of DD, (2) milking parlor suitable for in-parlor M-scoring and (3) willingness to participate in the study. During the farm visit, DD prevalence was determined and a DD risk assessment (RA) survey done. At the end of the visit, farmers were given a list of cows with M2-lesions, eligible for treatment. The DD RA survey was an interim version of the lameness RA questionnaire (University of Calgary). It consisted of 22 MCQ with sections on foot health, housing and general management. Each answer was given a risk score based on published literature, with higher scores indicating higher risk for DD. Risk scores of all questions summed up to a total risk score (TRS). Two veterinary students, one in 2016 and one in 2018, performed the farm visits and were trained in M- and leg hygiene scoring using published literature, classroom training with digital color photographs and in-parlor scoring of washed hind feet of around 50 dairy cattle using a mirror glued on a spatula and a powerful headlight. Dairy herd improvement data were extracted from farm management software with consent.

Before the start of the study, farmers and their veterinarians were invited for a DD meeting. Study design together with general information on DD and its control on dairy farms were presented. In 2016, one-page summaries with advice on DD control were compiled and emailed to the farmers and their veterinarians after completion of all farm visits, in 2018 these were compiled and emailed within 14 days following each farm visit. At the end of the study, farmers and their veterinarians were again invited for a group meeting where anonymized results were presented.

Descriptive statistics were calculated for TRS (% of maximum risk score) and herd DD prevalence (cow level). The association between TRS and DD prevalence was tested using linear mixed model (LMM) analysis with TRS as predictor and DD prevalence as outcome variable, year as factor and herd as random effect. The association between  $\Delta$ TRS (2018-2016) as predictor and  $\Delta$ DD (2018-2016) prevalence as outcome variable was visualized with a scatter plot.

In 2019 farmers and veterinarians were asked via email what they had done with the given advice in both study years.

## Results

Table 1. Descriptive statistics for TRS and DD prevalence of 19 Dutch dairy herds

Variable	Year	Mean	SD*	Minimum	Maximum
TRS (%)	2016	42	13	13	65
	2018	41	13	20	68
DD prevalence (%)	2016	39	13	15	59
	2018	49	10	27	69
$\Delta$ TRS (%)	-	-1	9	-17	16
$\Delta$ DD prevalence (%)	-	10	11	-14	31

\*SD = standard deviation

LMM analysis identified that higher TRS was associated with higher DD prevalence (0.45, 95%CI 0.19-0.73) and DD prevalence was higher in 2018 compared with 2016 (10.48, 95%CI 3.47-17.50). Scatter plot indicated that there was no important relation between  $\Delta$ TRS and  $\Delta$ DD prevalence.

For the email survey regarding action on advice given in 2016 and 2018, the response rate from farmers was 53% (10/19), with 4 farmers indicating some form of change in their DD management in 2016 and 7 farmers in 2018. The response rate from veterinarians was 89% (8/9) for 2016 and 90% (9/10) for 2018. They had discussed the advice and DD control with the farmer, but the majority admitted lack of follow-up.

## Conclusion

The DD RA survey can be used to raise awareness of strong and weak points of DD control on dairy farms. However, veterinary advice based on the DD RA survey is insufficient to initiate behavioral change, in both farmers and veterinarians, that results in a decrease in DD prevalence under field conditions.

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# **Promoting farm advisor engagement and action toward the improvement of dairy cattle lameness**

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## Objectives

To use qualitative participatory methods to facilitate the formation of lameness management advisory groups with aims to 1) promote advisor engagement with one another to develop lameness action plans, and to 2) explore participants' experiences of the groups through interviews and thematic analysis.

## Materials and methods

Thirteen advisors (5 hoof trimmers, 4 nutritionists, and 4 veterinarians) from Minnesota, USA were recruited for the project, for which they attended planning meetings, a workshop, lameness advisory group meetings, and developed lameness action plans for 10 dairy farms. Advisors were interviewed at the end of the project to document their experiences of the lameness management groups and their interactions with one another. Interviews were audio-recorded, transcribed verbatim, and common themes identified through thematic analysis.

## Results

Participants shared predominantly positive views toward the project and voiced appreciation about the quality of discussions and opportunity to connect with other advisors. Advisors reported improved communication with others via sharing reports and farm information, as well as increased confidence in reaching out to other advisors. Reported challenges included difficulty of bringing lameness management issues to the farmer when that may not fit within the farmers' goals or priorities, as well as participants' questioning other advisors' knowledge and intentions.

## Conclusions

This study describes a promising avenue of facilitating advisor engagement, though more work is needed to determine if further engagement translates to on-farm improvements in lameness management.

# Effects of a workplace physical exercise intervention on strength: The case of Anka, a hoof-care company

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## Introduction

The mechanization of workplaces has led to an accumulation of repetitive tasks and a reduction in physical activity requirements, especially in those job positions that were originally very physically demanding, such as the case of hoof trimmers. This situation threatens the workers' health due to the risks associated with repetitive stress injuries and sedentary lifestyles, resulting in an increase in absenteeism and a reduction in productivity. To address this issue, physical training programs in the workplace have expanded, resulting in several health-related benefits. Among these programs, high-intensity interval training has shown positive effects on quality of life and strength, even with short periods of activity.

## Objectives

Thus, the aim of the present study was to analyze the effectiveness of a (HIIT) intervention conducted in the workplace on strength outcomes in a sample of hoof trimmers.

## Material and methods

A pre-experimental design with pre-test and post-test was performed after a two-month training intervention with 11 employees of a hoof-care company (Anka), 5 office workers and 6 hoof trimmers. The training (Witrein) consisted of 4 one-hour session and 13 15-minutes session of whole-body and multiple-joint exercises. The evaluation included nine maximal strength test using a dynamometer.

## Results

Significant improvements in strength were obtained showing large effect sizes ( $p < 0.05$ ; Cohen's  $d > 0.8$ ) in the shoulder internal and external rotators, shoulder extensors, hip flexors and knee flexors tests, observing a tendency of progress in all remaining tests at a descriptive level.

## Conclusions

These findings support that a workplace physical exercise intervention improves strength of the employees, contributing to a better physical condition. Future research is needed to refine the protocols of these programs as well as to study further potential physical, psychological and social benefits associated with physical exercise so that they can be transferred to the companies and contribute to the well-being and the productivity of workers.

# **The multiple, scaled realities of farmed animal lameness in northern England**

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## Objectives

This paper presents findings from in-depth qualitative research with farmers and farm advisors on lameness in sheep and cattle in the north of England. We draw on anthropological work by Annemarie Mol (2002) on the human disease atherosclerosis, to explore the multiple realities of lameness in sheep and cattle, how these are associated with the scale at which lameness is enacted by farmers, farmer advisors and farm animals, and the implications this has for the communication of messages about the management of lameness between different stakeholder groups.

## Materials and methods

We utilise the findings of in-depth interviews conducted with 29 farmers from the north of England, and 21 UK-based farm advisors (e.g., veterinarians, foot trimmers, etc.). Ethical approval was obtained prior to data collection, and all participants provided either written or oral consent prior to participation. Interviews took place between September 2019 and March 2021. Initially these were conducted in-person, with later interviews conducted remotely due to Covid-19 restrictions. All interviews were audio recorded and transcribed verbatim. Transcripts were coded via Nvivo software using a codebook developed by the authors and thematically analysed. The results also draw from observational fieldwork at 11 of the farms as part of a ‘farm walk’ with the interviewees, during which notes and photographic data were produced. We present the findings using a scaled framework which emerged from the ways in which interviewees described the practices of interacting with and managing lameness. This explores the foot, animal, farm and national scales.

## Results

At the foot, lameness is visceral and sensory, involving smell, touch, sight. The condition is observed and acted on by farmers and advisors in isolation from the rest of the animal’s body. Farmers, foot trimmers and sometimes vets are actively involved at this scale, however the animals themselves are not. At the animal scale, sensory descriptors are still mentioned, but sight is dominant, especially in terms of observing movement. Human and non-human relationships become important, for example, knowing an animal’s typical behaviours and individual history and descriptions of animals’ emotions. This is aided by farm records, such as production data and animal pedigrees. At this scale the animal becomes an active co-creator in ‘doing’ lameness along with farmers and advisors. At the farm scale, the sights and behaviours of groups of animals become key, e.g., the herd/flock, management groups, or age cohorts, as well as differences between breeds and species. Knowledge of the geography and history of the farm and variations in seasonality and climate aid in knowing and managing lameness. At the national scale, lameness becomes a moral issue and considerations of how good welfare is understood and practiced becomes a key in understanding and responding to the condition. Lameness is frequently mentioned by advisors as statistics, e.g., average rates and percentages within the

national herd or flock, rather than as an issue of individual animals. These statistics are then used as tools to benchmark rates of lameness and evaluate practice at smaller scales.

### Conclusions

This paper presents a novel way of viewing lameness in sheep and cattle, describing how the multiple realities of the condition are associated with the different scales at which it is enacted. These findings have implications for the way messages related to the management of lameness are conveyed between for example, farmers, veterinary professionals and policy makers. Firstly, we suggest there needs to be a better appreciation of the different ways lameness is known and enacted when considering the framing of messages aimed at farmers and their advisors. Secondly, overlap exists between the ways in which lameness is known at these scales. Identifying these presents opportunities for more effectively targeting communication between stakeholder groups.

# **Evaluating the efficacy of two footbath concentrates to control digital dermatitis in free-stall dairy cows using a non-inferiority study**

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## Objective

Our primary objective is to determine if a commercial footbath concentrate (Healmax®) is non-inferior to a copper sulfate concentrate in the prevention of new cases of digital dermatitis (DD). As a secondary objective, we will investigate the comparative efficacies of the two products in the control of chronic DD cases.

## Materials and methods

Five Holstein and Holstein-cross herds ranging from 1323-2292 cows/herd were enrolled in the study starting December 2021. Treatments were allocated randomly at the pen level to the test product (HM; 2.5% concentration) or to a Copper Sulfate (CS; 5% concentration) footbath solution. Footbaths are run 4d/wk, once per day, for a 4-month time period, with footbaths changed after every 200-400 cows. All lactating cows are scored in the milking parlor every two weeks for DD by trained observers, including baseline evaluations prior to the study start. Using the M-based scoring system, a score of 0 denotes no lesion being present and 4H, 4P, and 2P being lesion categories of increasing severity. Herd-level data is extracted during each farm visit from farm DairyComp 305 software. Outcomes for DD will be measured at the leg level (rear legs only). For the study sample size calculations, a 5% incidence risk of new DD infections and a 25% non-inferiority margin has been used. Data will be analyzed using a linear mixed model to account for cow and herd level effects.

## Results

This study is ongoing and, therefore, a preliminary analysis of changes in DD score prevalence on 3/5 farms at baseline (-1 wk relative to study start) and at the study midpoint (+8 wk) are presented. Prevalence is presented as a pen-level average, with lesions scores based on the highest score of the two rear legs. The proportion of scores in each lesion category was largely similar between treatments at both the baseline and midpoint evaluation for Farm 1 and 3. Farm 2 had a numerically lower number of cows scored as 0 at baseline (HM = 35%, 95% CI: 28-42; CS = 34%, 95% CI: 28-40) than at the midpoint evaluation (HM = 63%, 95% CI: 56-70; CS = 64%, 95% CI: 58-71). This consequently resulted in a reduction of more severe lesion scores at the midpoint evaluation. The proportion of scores across lesion types for this farm remained similar between the two treatments, with the proportion of each lesions category for HM and CS pens differing by no more than 4% at either time point. Farm 3 experienced a larger increase in number of cows scored zero at the midpoint compared to baseline for the CS pens, at 64 % (95% CI: 56-71) vs. 73 % (95% CI: 67-80), than for the HM pens, at 76% (95% CI: 70-83) vs 78 (95% CI: 72-85). These descriptive results are preliminary and our final analysis will be done at the cow level to adjust for cow movements, age and stage of lactation.

### Conclusions

Preliminary results from our pen level analysis suggest that the commercial footbath concentrate is performing at a level that is comparable to that of Copper Sulfate in maintenance of DD stages.



# **Does a new water-cooled cubicle mattress used in summer in early lactating dairy cows affect cow behaviour and decrease lameness incidence? A clinical randomized trial**

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## Objectives

To assess if a new heat abatement system – a water-cooled cubicle mattress – used in hot periods could decrease lameness incidence in peak to mid lactation, assuming the cows on water-cooled cubicle mattress would spend less time standing and more time feeding in early lactation.

## Materials and methods

A randomized clinical trial was implemented on a commercial dairy farm of Western France from 14 June to 31 December 2021. A competent ethics committee had approved the experiment (authorization # CERVO-2021-14). At calving, cattle were randomly allocated to one of two adjacent barns, equipped with either a conventional cubicle mattress (Louisiane mattress; Bioret-Agri, France) or a cubicle waterbed (Aquaclim; Bioret-Agri, France). The cows were moved to another barn at around 150 days).

The temperature-humidity index (THI) was calculated from the climatic parameters of the barns (air temperature, relative humidity) recorded every 15 minutes. The behaviour of the cows was continuously monitored using computer vision (Alherd; France). In addition, daily rumination and ingestion time were recorded by a neck collar comprising a tri-axis accelerometer and microphonic sensors (Lely Qwes HR; Lely France). All treatments were registered by the farmer. Cows' feet were trimmed by an expert hoof-trimmer at the beginning and end of the trial. Gait was scored by two of four trained observers every fortnight.

A slightly hot day was considered as a day with a THI >68 occurring between 3 and 12 h, a moderately hot day as a day with more than 12 h with a THI >68 but less than 12 h with a THI >72, and a very hot day with more than 12 h with a THI >72. Average daily standing, feeding, ingestion and rumination times, as well as cow comfort indices (CCI: proportion of cows touching a stall that are lying down; SUI: proportion of cows that are in the pen, not feeding, and that are lying down in the stalls; SSI: proportion of cows touching a stall that were standing with all 4 feet on the stall platform or perching with the front 2 feet in the stall and the rear 2 feet in the alley), were analysed by linear regression analysis taking into account intervention group (Louisiane vs. Aquaclim), cow characteristics, treatments and THI indices as covariates. The incidence of lameness was analysed by Cox proportional hazards regression models, controlling for intervention group, cow characteristics and THI indices as covariates.

## Results

At the start of the trial, cows were mainly affected by digital dermatitis, with a significantly higher proportion of cows with active lesions in the intervention group (28/44 vs 42/51 cows with a least one M1 or M2 lesion in the control and intervention groups, respectively;  $p = 0.04$ ).

Between June 14 and September 30, 102 days were slightly hot, 26 moderately hot and 16 very hot. 83 cows calved during this period. In their first 30 DIM, on median 6 days were considered as slightly hot (min – max: 0 – 12 days), 1 day moderately hot (min – max: 0 – 7 days) and 0 days very hot (min – max: 0 – 5 days).

Of the 58 cows that were sound at their first post-calving assessment (32 and 26 in the control and intervention groups, respectively), 41 developed lameness before 150 DIM (75% and 65% in the control and intervention groups, respectively;  $p = 0.42$ ), at a mean of 68 DIM (69 and 68 DIM in the control and intervention group, respectively;  $p = 0.83$ ).

No statistically significant difference could be demonstrated in the survival analyses between the two groups for the incidence of lameness. There was only a trend towards an increased risk of becoming lame with at least on day with a maximum THI >72 between 2 and 14 DIM ( $p = 0.09$ ) or with at least 3 moderately or very hot days between 2 and 14 DIM ( $p = 0.07$ ).

*Results on behaviours were not available at the time of writing.*

## Conclusions

Water-cooled cubicle mattress used in summer could be interesting to decrease lameness in fall, but this could not be demonstrated in this study. Further studies with a larger sample size and in herds more prone to claw lesions are needed to draw a firm conclusion.

*Results on cow behaviour are still pending.*

# **Effects of intermittent application of a nurturing product and a disinfectant via a hoof mat on the prevalence of digital dermatitis in dairy cows**

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## Introduction and objectives

Digital dermatitis is a disease caused by bacteria (*Treponema* spp., *D. nodosus*) that affects the skin on the heel of dairy cattle, resulting in very painful lesions on the skin above the horn of the hooves. This may cause reduced animal welfare and technical performance, as well as economic losses (Palmer and O'Connell, 2015; Solano et al., 2017).

In current production systems, footbaths are typically used to cure and prevent digital dermatitis. A footbath is filled with a solution of disinfectants, such as copper sulphate or formaldehyde and 150 up to 200 dairy cows are walking through. Disadvantages of footbaths are manual filling, organic contamination and a decay in efficacy, and impaired skin health.

New solutions for automatic hoof care can contribute to improved hoof health (Speijers et al., 2010). Also, programs with disinfection and skin care can be combined and manual labour can be reduced. The objective of this project is to investigate the effect of an automatic preventive hoof care concept on the prevalence of digital dermatitis in dairy cows.

## Materials and methods

The tested concept (MS AutoHoofClean) involves a dosing unit which is connected to a hoof mat which flushes the claws. The mat has a length of 200 cm, a width of 100 cm and a depth of 7.5 cm. The mat was intermittently filled (6 to 9 times per day) with a solution that cleans and nurtures the skin around the hooves (MS HoofClean, a PH skin neutral solution containing Fatty Alcohol C10, ethoxylated and Citral) and with disinfectant solution (MS FormaDes). Filling occurred automatically and multiple times per day. In the current study, this concept was tested at practical dairy farms with milking robots (n=3) and milking parlours (n=3).

The hoof mat was placed at the exit of the milking robot. Farms with a milking parlour were equipped with 2 serial mats at the exit, because cows have more passages over the mat with milking robots (4-6 times per day) than with the milking parlour (2-3 times per day).

Prevalence of digital dermatitis was scored by independent hoof trimmers in the Dutch National Recording system during claw trimming at the beginning and end of the studies, i.e. after approximately 3 months. The scores were divided in 3 categories: M1, beginning lesions; M2, active lesions and M4.1, chronic digital dermatitis (according to the ICAR standard).

## Results

Results from the studies with the hoof mat are summarised in Table 1.

Table 1. Effects of a novel automatic hoof care concept on digital dermatitis

	n		#hooves with digital dermatitis								
Treatment	farms	cows	Start				End				New Cases
			M1	M2	M4.1	Total	M1	M2	M4.1	Total	
1. Hoof mat at milking robot farms	3	315	121	61	40	222	72	32	11	115	28
percentage of cows			38%	19%	13%	70%	23%	10%	3%	36%	9%
2. Hoof mat at milking parlour farms	3	371	52	63	27	142	29	27	9	65	19
percentage of cows			14%	17%	7%	38%	8%	7%	2%	17%	5%

Applying the hoof mat concept reduced the number of hooves with digital dermatitis by approximately 50% and resulted in a low incidence of new cases at both milking robot and milking parlour farms (Table 1). Implementation of the concept did not negatively impact the frequency of visiting the milking robots, and ethological observations did not show any aversive behaviour towards the hoof mat.

### Conclusions

These initial studies with a novel concept, including intermittent application of a nurturing product and a disinfectant via a hoof mat, showed that digital dermatitis was substantially reduced in dairy cows. The concept reduced existing infections of digital dermatitis and prevented emergence of new cases. Therefore, these farm trials indicate that a combined approach with nurturing and disinfecting products may contribute to the improvement of claw health in dairy cows.

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## **Case study. Trainings on low stress cattle handling. Perception and impact on Spanish hoof trimmers**

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### Objectives

Primary objective is to establish a learning methodology for improving animal welfare through proper cattle handling at the time of trimming. The objective of this poster is to evaluate the perception and impact of Low Stress Cattle Handling training on the daily work of the Spanish hoof trimmers.

### Materials and methods

With the objective of improving animal welfare, in 2020 we started a training plan focused in low stress cattle handling. Due COVID situation we combined on-line trainings with face-to-face meetings. We worked at 3 levels.

First level was the Spanish and Portuguese Hoof Trimmer Association (APPB). Under the APPB umbrella, different actions were driven. These training sessions started with an online training session (A. Gonzalez, November 2020) and continued by an on-farm training (Summer Trimming School, September 2021). In order to promote low stress cattle handling among APPB members, a virtual contest to select the best cattle handler was organized. Members sent videos and best one was selected by all the members. This competition has been organized for two consecutive years (2021 and 2022).

Secondly, at a company level, once a month ANKA organized breakfast meetings with the objective of present cases studies and share experiences. During 2021 main topic of these meetings was low stress cattle handling.

Third level was farm level. This level combined farm workers training and direct intervention on the trimming day. From the breakfast meetings described above, we selected some farms where room to improve was detected by trimmers. After discussing and agreed with farm manager an ANKA veterinarian went to the farm with the objective of training the staff and make a direct intervention on the day of trimming. In addition, some farmers testimonials were recorded and sent by WhatsApp.

Early 2022 a survey was sent to all the APPB members (78 members). A soft copy of the questionnaire was sent using WhatsApp diffusion list and email list of the association. 11 questions were selected to collect their perception and evaluate the impact of this kind of training on their daily work. All questions were evaluated from 1 to 5, being 1 no impact and 5 maximal impact.

Same questionnaire was sent to the farms where intervention was done. At the time of presenting this abstract, farmer opinions are still being collected.

### Results

72% of members of the association answered the survey. They consider that the use of low stress cattle handling before training was moderate (3.06 out of 5). About the importance of low stress cattle training most of them consider very important (4.89 out of 5). Regarding the impact of this training on his daily work the impact was high (3.96 out of 5). On their opinion the most important impact after using low stress cattle management techniques has been cattle welfare, milk production and trimmer welfare (the 3 most ranked items on the questionnaire).

### Conclusions

Low stress cattle handling is perceived by Spanish hoof trimmers as an important issue and something worth investing in. Combination of online training, on-farm training and game playing (contest) looks like a good way of promoting low stress cattle handling among trimmers. Further research is required to evaluate the real impact of low stress cattle handling during trimming.

### Acknowledgement

The authors want to thank the APPB members for their participation on that project.

# **Randomised control trial comparing the efficacy of a topical organic acid and tea tree oil treatment with licensed topical oxytetracycline for the treatment of Digital Dermatitis in dairy cattle**

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## Objectives

The study aimed to compare the efficacy of a commercially available topical treatment for digital dermatitis (Konquest hoof gel, Provita, Northern Ireland), which contains a mix of organic acids (including Salicylic acid) and tea tree oil, against the licensed topical antimicrobial spray containing oxytetracycline (positive control).

## Materials and methods

Dairy cattle were enrolled from six English dairy farms. Cows were screened for active digital dermatitis lesions via direct observation of the heels at hoof trimming. The M-scoring scale was used to define digital dermatitis lesions. Cows with any non-regressing (M1, M2, M4, M4.1) digital dermatitis lesions on the hindfeet were eligible for enrolment onto the study.

The cows were then randomly allocated into a treatment group using a random number generator. One treatment group (Gel) received Konquest hoof gel applied onto the lesion using melolin wound dressing under a light cohesive bandage. The positive control group (Spray) received topical application of oxytetracycline spray (Engemycin, MSD or Terramycin, Zoetis) onto the clean, dried lesion with no bandage. After 30 seconds of drying, spray was reapplied to the lesion.

The recruited cows underwent blinded re-assessment of lesion M-scores in the parlour 28 days after treatment. Lesions ended up with two M-scores; one at enrolment and one 28 days post treatment. Lesions were then classified as either healing/ apparent cured, improved, static or worse.

Definitions of these classifications are as follows; Healing/apparent cure M1, M2, M4, M4.1 to M0 or M3, Improved M1 to M4 and M2, M4.1 to M1, Static M1, M2, M4, M4.1 to the same score and Worsened M4 to M1, M2, M4.1.

These classes were then defined as healing/apparent cure and not cured, cured being any lesion progressing from an active lesion to M0 or M3 and non-cured any lesion progressing to any other classification other than M0 and M3.

Sample size calculations used an 80% power with 95% confidence interval based on 10% difference in cure rate at 28 days. This stated 142 cases were needed in each group.

Ethical approval was obtained through the RCVS and approved by the RCVS Ethics review panel.

Statistical analysis was carried out using Microsoft Excel and R (R Core Team 2020).

### Results

Cases were enrolled from January 2019 to January 2022. 320 cases were enrolled in total with follow up data collected for 284. Of the 320 lesions at enrollment, 147 were M-score 2 (46%), 56 were M-score 1 (18%), 54 were M-score 4 (17%) and 47 were M-score 4.1 (15%).

284 cases were seen again at 28 days and scored. Overall, 71.1% cases were classed as cured, 16.5% cases classed as improved, 3.2% cases classed as worsened and 9.2% cases classed as static.

The M-score progression between treatment groups were as follows; Cured with Spray 76.30% and Gel 66.44%, Improved with Spray 14.80% and Gel 18.10%, Static with Spray 6.70% and Gel 11.40%, Worse with Spray 2.20% and Gel 4.02%. For statistical analysis, cases were classed as cured (n= 202) and non-cured including improved, worsened and static cases (n= 82). The two treatment groups Spray and Gel were then compared using a Chi-squared test, there was no significant difference found ( $P=0.16$ ) between the two treatment groups.

### Conclusions

The two treatment groups have shown no statistical difference between lesion cure rates when using M-score classification. In this trial Provita gel performed as well as a single treatment of Oxytetracycline spray on individual animal treatments. This product has the potential to help reduce antibiotic use on farm for uncomplicated digital dermatitis lesions.



# **Evaluating transdermal flunixin-meglumine in treatment for white line disease in dairy cows**

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## Objective

To evaluate the effect of transdermal flunixin-meglumine on healing and reproductive performance in lactating dairy cows with white line disease (WLD).

## Material and methods

The study was performed in a commercial dairy farm with 2.500 lactating cows in the North East of Spain in 2019. Cows were included in the study if they had WLD in one hoof (cows were excluded if they had other hoof lesions), 0 - 120 days in milk and no other health problems (mastitis, metritis, etc.) or medical treatment in the 30 days prior enrollment. The day of enrollment (day 0) a functional trimming for the WLD affected hoof and a block treatment for the healthy hoof was performed in all cows. Additionally, cows were randomized into one of both treatment groups: anti-inflammatory treatment with a single dose of flunixin pour-on administered on day 0 (group FTD, Finadyne® Transdermal 50 mg/ml, MSD AH) or without anti-inflammatory treatment (control group). Cows were re-evaluated in the hoof trimming chute between Day 7 to 21 after enrollment. The progress of the lesion was considered as healing if the hoof was reconstructed and no blood was present. Additionally, conception rate was evaluated for animals inseminated between -30 to +60 d of enrolment (n=31). The following data was recorded for each animal: days in milk, parity (primiparous vs. multiparous), affected limb (fore vs. hind limb) and hoof (medial vs. lateral), size of the lesion depending on the size (small vs. large), healing rate and conception rate. Data were analyzed by Chi square's test using SPSS 18.0 (SPSS, Chicago, USA).

## Results

Fifty cows were included in the study (23 were primiparous and 27) multiparous cows. Twenty-eight cows were in the control group and 22 in the FTD group). The lesions registered were 33 small and 17 large lesions, affecting 29 cases the fore limb and 21 the hind limb, and being 31 and 19 in the lateral and medial hoof, respectively.

Our results showed that 50% of the cases did not progress to healing at the follow up evaluation. At this evaluation it was necessary to place a new block in 20% of the cows. Cows with a WLD on the rear medial hoof had an increased healing rate in the FTD group compared to control animals [10/17 (58.8%) vs. 3/14 (21.4%);  $p<0.05$ ]. Additionally, cows in the FTD group with a lesion on the rear medial hoof of the hind limb had better healing than control cows [4/4 (100%) vs. 1/3 (33.3%),  $p=0.05$ ]. When primiparous cows were analyzed, FTD animals showed an increased healing rate compared to control cows [8/14 (57.1%) vs. 2/9 (22.2%);  $p=0.09$ ], with no evidence for an interaction between limb or hoof.

Cows with large hoof lesions had a decreased conception rate compared to cows with smaller lesions [12/22 (54.5%) vs. 0/9 (0%);  $p < 0.05$ ].

### Conclusions

Overall healing of WLD was low and our results show that the use of flunixin transdermal should be considered as an adjunct to therapy to improve the healing rate for WLD lesions for WLD on the rear medial hoof.

\*WLD = White Line Disease, FTD = Finadyne Transdermal

# **Evaluating the effects of USDA organic approved therapies on foot rot**

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## **Objective**

Foot rot is an infectious disease that can cause severe lameness and permanent damage, if treated improperly. This disease is caused by a physical abrasion or tear in the interdigital skin that often leads to an infection in the subcutaneous tissue. Clinical foot rot can be characterized by symmetrical swelling, redness, and foul odor depending on severity. Early detection, removal of necrotic tissue, and antibiotic therapy have been an industry standard when treating foot rot on conventional dairy operations. Managing foot rot cases on USDA certified organic dairy operations requires the use of non-antibiotic therapies, and few evaluations of these products have been reported on. The lack of evidence-based treatment recommendations puts organic producers at risk of prolonged lameness and delayed healing for animals diagnosed with foot rot. The objective of this prospective randomized clinical trial was to evaluate the effectiveness of four topical non-antibiotic alternatives for the treatment of foot rot on U.S. organic dairies.

## **Materials and methods**

Two hundred and forty lactating dairy cows were enrolled and randomized into four treatment groups between April of 2018 and December of 2020. Locomotion scores for each animal were recorded by a trained veterinarian prior to the animal's treatment. At each evaluation, the animal was restrained in a hoof trimming chute, the lesion was cleaned and any necrotic tissue was removed. In addition, rectal temperature and physical assessments of generalized foot swelling and the presence of a skin fissure were recorded. Enrolled animals were randomized into one of four treatment groups: a) copper sulfate and water, b) seven percent iodine tincture, c) organic honey, or d) hydrogen peroxide. All treatments were applied along with a light bandage. Animals were scheduled for re-evaluation on D 7, 14, 28, 56, and 112. The randomized treatment was applied on D 0, 7, and 14. Statistical methods included mixed linear models for: a) absolute locomotion score at each observation day, and b) change in locomotion score from the previous observation. Full-factorial models of treatment \* day effect were built. Meanwhile, survival analysis using Cox proportional hazards regression for time-to-recovery (defined as days to locomotion score=1 and no swelling of the foot, or else right-censoring on or before D112) also was deployed. Since this study was performed on a USDA certified organic operation, it was not possible to include a systemic antimicrobial treatment group, the gold standard of therapy in conventional operations. All animals were monitored for welfare issues associated with treatment failure and processes in place to manage such situations without compromising the welfare of the animal.

## **Results**

The results of this study showed statistically significant differences in the time-to-recovery among several treatment groups. All treatment groups showed a consistent decline in locomotion score by D112. The hydrogen peroxide treatment group returned to a locomotion score 1 and showed no signs of swelling more quickly than the iodine group (referent category). The

proportional hazard for recovery of hydrogen peroxide-treated cows was 1.577 times higher when compared to iodine-treated cows ( $p=0.028$ ). The hazard ratio of honey-treated cows was 1.49 times greater compared to iodine-treated cows, though this was just short of statistical significance ( $p=0.054$ ). Hydrogen Peroxide proved to be the most effective antibiotic alternative for the management of foot rot when compared to the other treatment groups, while iodine showed consistently worsened results and prolonged negative effects on lesion healing.

### Conclusions

Hydrogen peroxide was the treatment group with the most rapid lesion healing. There was a significant difference when comparing both hydrogen peroxide or honey to the slowest healing treatment, iodine. Hydrogen peroxide may illicit a more rapid healing response due to its oxidative effects on anaerobic bacteria associated with foot rot. All treatment groups showed evidence of healing by the end of the trial. Due to the restrictions of this study, we did not have an antibiotic treatment group to compare with and thus cannot comment on the comparison of hydrogen peroxide and antibiotic therapy.

# **Preliminary results of preventive spraying with a product containing aluminum and zinc in the milking parlor to prevent DD lesions**

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## Objective

Digital dermatitis (DD) is an international problem on beef and dairy farms and predominantly caused by *Treponema* spp. (1,2) The infection with this most important infectious claw disease in cattle leads to damaged skin with erosive and painful lesions (3). A good on farm prevention strategy can reduce treatment costs, improve animal welfare and enhance a better long-term effect. To reduce the amount of dispensed drugs and number of lame animals it is necessary to establish a good long term on farm strategy (4). In this study a product containing aluminum sulfate complex and zinc sulfate as a monohydrate is tested as a preventive spraying solution in dairy herds affected with DD. It will be evaluated if the product has an impact on the occurrence of DD.

## Materials and methods

The trial takes place on two different German dairy farms, which milk 70 cows on average respectively. In addition to the milking herd, dry cows and heifers that are due to calve within the next two months were integrated into the study. While routine hoof trimming every cow/heifer were additionally scored for DD (DD-M0 to DD-M4.1) in the trimming chute and treated according to the lesion that was found. Every animal with an DD-M1 lesion > 1,5 cm, a DD-M2 lesion, a DD-M4 or DD-M4.1 lesion was wrapped with a 66% Methyl-salicylic acid ointment for 6 days. Each DD-M0, DD-M1 <1,5 cm, DD-M3 or DD-M4 <1cm were sprayed with a copper- and zinc-chelate spray. After taking off all bandages no open DD-lesions were left. Lesion type and degree of severity were evenly distributed between the two hind legs and on both farms. Thus, it was possible to specify the two hind legs of an animal as treatment and control group respectively. Fourteen days after hoof trimming the implementation of the preventive spraying with a backpack sprayer in the milking parlor started. The used product contains an aluminum sulfate complex and zinc sulfate as a monohydrate. The test product was sprayed during the first 5 weeks three times per week and since then two times per week during one milking period per day. Heifers and dry cows were sprayed while fixed in the head locks.

Every 4 weeks the hind feet of the cows are scored in the parlor and every 4 months a reevaluation in the trimming chute is done simultaneously on the farms.

## Results

During the first scoring 139 animals total were scored in the hoof trimming chute. Each scored lesion is allocated a value based on size and severity of the lesion (DD-M1=1-3points, DD-M2=30-60points, DD-M3=4-6points, DD-M4=15-17points, DD-M4.1=20points). The total score at the end is a comparable value to assess the positive or negative development of the lesions and therefore the effect of the treatment in comparison to control. In the control group There were 32 DD-M2 lesions of all sizes (43%), 0 DD-M3 lesions (0%), 26 DD-M4 lesions of all sizes (35%)

and 16 DD-M4.1 lesions of all sizes (22%) (total score 2.081). The score was complemented with 39 DD-M2 (50%) of all sizes, 0 DD-M3 (0%), 20 DD-M4 (25%) of all sizes and 20 DD-M4.1 lesions (25%) of all sizes on the treatment group (total score 2.152).

After 21 days of the implemented, on-farm protocol the scoring of 138 animals in the milking parlor took place. There were 11 DD-M2 (12%) all sizes, 0 DD-M3 (0%), 69 DD-M4 (79%) all sizes and 8 DD-M4.1 (9%) all sized lesions on the control group (total score 1.316). The score was complemented with 1 DD-M2 (1%) all sizes, 9 DD-M3 (13%) all sizes, 60 DD-M4 (85%) all sizes and 1 DD-M4.1 (1%) all sized lesions on the treatment group (total score: 948).

### Conclusion

After the short term of the first trial weeks, data show a significant positive effect of the treatment in comparison to the control group. A longer follow-up period is needed to observe the development of the hitherto positive effect of the treatment. Statistical analysis will be done and presented on the conference to show if the differences are statistically significant, too.

# **Local treatment of interdigital phlegmon (footrot) by the regional intravenous administration of Tylosin in cows**

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## **Introduction**

Interdigital phlegmon (IP) or footrot is a common infectious disease in bovine. It produces lameness in dairy cattle and feedlots. In some severe cases, the animal does not respond favourably to the parenteral administration of antibiotics such as tylosin or ceftiofur. Possibly, the farmer does not pay enough attention and treats without veterinary supervision. There are some studies conducted with the intravenous regional administration of quinolones in IP treatment. (Varsano et al., 2015.; Celani et al., 2017). Due to the current EU regulation on the use of antibiotics, quinolones and cephalosporines (category B) can only be used in the case of laboratory tests that justify their use. The hypothesis of the study is that IP could be treated by regional intravenous tylosin rather than the use of quinolones.

## **Objective**

The objective of the study was to evaluate the efficacy of IP treatment by the regional intravenous administration of tylosin and a tourniquet for 3 consecutive days.

## **Materials and methods**

The study was performed in 19 cows diagnosed with IP during May 2019 to February 2020. The affected cow breeds were 18 Holstein and one beef cattle (Asturiana de los Valles). The animals were housed in free-stalls with cubicles (n=10), tie-stall (n=4) or tie-stall with a daily pasture exit (n=5). A tourniquet was maintained for 30 min before the intravenous administration. This tourniquet consisted of three flat rubber compressors.

After application of the tourniquet, one-third of the systemic dose of tylosin (PHARMASIN 200 MG / ML) was administered through the saphenous vein, cephalic vein or common dorsal digital vein (10cc of PHARMASIN tylosin 200 MG / ML). The treatment was repeated for 2 more days. The antibiotic administration was carried out with a butterfly Venofix 23G 0.65x 20mm and 30 cm length of plastic conduit to avoid movement issues.

In order to evaluate the effectiveness of the treatment, the locomotion score (LS) was evaluated on days 1, 3, 5 and 15 based on the 5-point scale of Sprecher et al., 1997. The measurement of the limb circumference was also done at 1 centimetre below the accessory hooves and 1 cm above the accessory hooves on days 1, 2, 3, 5 and 15.

## **Results**

IP was diagnosed in all of the limbs: Right forelimb (5.3%; n = 1) left forelimb (10.5%; n = 2), right rear limb (36.8%; n = 7) and left rear limb (47.4%; n = 9). The LS punctuation was as follow: day 1 – LS5 (31.6%; n=6), LS4 (52.6%; n=10) and LS3 (15.8%; n = 3); day 3 - LS4

(36.8%; n = 7), LS3 (31.6%; n = 6) and LS2 (31.6%; n = 6); day 5 - LS4 (10.5%; n = 2), LS3 (31.6%; n = 6) and LS2 (57.9%; n = 11); day 15 - LS4 (5.3%; n = 1), LS3 (5.3%; n = 1), LS2 (31.6%; n = 6) and LS1 (57.9%; n = 11).

The reduction of the measured circumference taken 1 centimeter above the accessory hooves was more than 0,5 cm from day 1 to 2 (73,7%; n = 14), day 2 to 3 (57.9%; n = 11), day 3 to 5 (68,4%; n = 13), day 5 to 15 (84.2%; n = 16) and, from day 1 to 15 the reduction was more than 1 cm (89,5%; n = 17). The reduction of the measured circumference taken 1 centimeter below the accessory hooves was more than 0,5 cm from day 1 to 2 (63,2%; n = 12), day 2 to 3 (57,9%; n = 11), day 3 to 5 (78,9%; n = 15), day 5 to 15 (84,2%; n = 16), and from day 1 to 15, the reduction was more than 1 cm (94,7%; n = 18).

### Conclusion

The tylosin treatment was administered to 19 animals. Results over 15 days showed that 17 of the 19 animals resulted in no lameness (LS 1, 2) vs 19 animals with lameness (LS 3, 4, 5) on day 1. In this study, the use of tylosin with a local venous application ended up in an effective alternative to the IP treatment vs the parenteral use of quinolones and cephalosporines.



# **Development of a hoof horn lesion induction model in Holstein cows: The next step in lameness research to allow for the evaluation of therapeutic and preventative interventions**

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## Objective

The objective of our study was to develop a sole ulcer induction model that can be used as a future tool in the evaluation of pain management and preventative treatment strategies of sole ulcers.

## Materials and methods

The study was an iterative process involving three phases and employed multiple challenges chosen for their association with risk factors for sole ulcer development in dairy cattle. Eight Holstein heifers were enrolled in Phase 1 (P1; n = 4 /group), running from -14 to 84 DIM, and randomly assigned as a control (CON1) or treatment (BLK-R1) group. The same cohort was enrolled in mid-lactation in Phase 2 (P2; n = 4/group), running from 135 to 235 DIM, with cows assigned to one of two challenge treatments (BLK2 or BLK-R2). In Phase 3 (P3), 12 Holstein heifers (n = 4/group), enrolled from -28 to 84 DIM, were randomly assigned to one of three groups: BLK-R3, BLK-LPS3, or CON3. Over the course of a challenge period (duration: 28 days in P1; 42 days in P2 and P3), challenges applied to BLK-R1, BLK-R2, and BLK-R3 cows included a hoof block, applied to the lateral hoof of the right hind leg, and varying durations and frequencies of lying restriction. The BLK-R3 cows were also restricted in DMI. The BLK-LPS3 cows received the same restrictions as BLK-R3 cows in addition to a lipopolysaccharide (LPS) challenge 1x/wk for the first three weeks postpartum. Control cows (CON1 and CON3) received no challenges. Lying time was measured continuously in all phases using leg-mounted pedometers. Visual locomotion scoring and hoof evaluations were conducted at various time points across each phase's study period. Additional measures of weight distribution using a weighing platform (P2 and P3) and blood, milk, rumination, and hoof thermography measures (P3) were also reported. As this research was intended as a proof-of-concept study, sample sizes were not selected to allow for statistical analysis of outcome measures. Results were evaluated descriptively.

## Results

No induction model across any phases was successful in inducing sole ulcers. However, sole hemorrhages on the rear right hooves, a precursor of sole ulcer development, were reported in challenge treatment cows in P2 (BLK-R2 = 5; BLK-LPS3 = 4) and P3 (BLK-R3 = 3, BLK-LPS3 = 2, CON3 = 0). The block placement and style were altered in P2 and P3, resulting in alterations in gait and a reduction in the proportion of weight placed on the blocked hooves of P2 and P3 challenge cows. Furthermore, increases in hoof temperature in P3 cows suggest that hoof blocks had an impact in these treatments compared to BLK-R1 and may have contributed to the better lesion results obtained. Lying restriction successfully altered total lying time on restriction days, but increases in lying time during non-restriction days indicates compensation for lying

restriction, possibly limiting the challenges' efficacies. Moreover, lying restriction was similar between P1 and P3, but P1 treatment cows, similar to CON1 cows, did not display changes in gait or develop hoof lesions. Metabolic challenges – DMI restriction and LPS challenges – added in P3 did not have any discernable effects over results yielded in P2, with no notable differences in blood glucose, NEFA, and calcium that would suggest metabolic stress necessary to induce a negative energy balance sufficient enough to impact hoof health. Higher concentrations of beta-hydroxybutyrate in BLK-LPS3 cows and depressed milk production may point to some success in inducing a negative energy state necessary to evoke potential causal sole ulcer pathways, but the small number of animals and variability in production makes it difficult to ascertain from the current study results.

### Conclusion

When applying 3 types of challenges – hoof blocks, lying restriction, and metabolic stressors – associated with sole ulcer development across three iterations of induction models, hoof blocks appear to be the most successful in inducing lesion development, though all failed to result in sole ulcers. Future iterations should include hoof block application, but look at altering the methodology for duration and frequency of lying restriction, including potential forced walking bouts, as means to improve induction model success.

## **Bovine digital dermatitis: Trick or treat**

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### Objectives

Investigate the efficacy of an enzymatic alginogel (alginogel) on M1, M2, and M4.1 (active) lesions of digital dermatitis (DD), compared with a gel containing copper and zinc chelates (coppergel), using (1) the M-score and (2) wound healing progress as outcome.

### Material and methods

The hind feet of 543 cows from 7 different Dutch dairy farms were foot trimmed and M-scored. Feet with active lesions were included in the study. Feet were alternately allocated to the alginogel or coppergel treatment group and photographed, treated and bandaged on day 0 and 3. On day 7, lesions were photographed and received a third treatment and bandage if the lesion was still an open wound. All treated lesions were photographed for evaluation on day 10, which was considered the end of the treatment period.

M-score improvement of DD lesions was defined as lesions that transitioned between day 0 and day 10 from M1 lesions to M0, M3, or M4; or M2 lesions that transitioned to M0, M1, M3, M4, or M4.1; or M4.1 lesions that transitioned to M0, M1, M3, or M4.

Wound healing progress of all treated and photographed lesions was assessed by a specialist in veterinary wound healing using skin necrosis, granulation tissue, granulation tissue level in comparison with the surrounding skin, granulation tissue necrosis, wound contraction, and epithelization as criteria. Wound healing progress of pairs of photographs of the lesions on day 0 and day 10 were scored as 'improved', 'equal', 'worsened', or 'unable to score'. Lesions with improved wound healing had at least 1 of the following criteria when compared with the previous observation: decreased defect size, healthier granulation tissue color (pink-red instead of purple-grayish), more regular aspect of granulation tissue surface, wound contraction, or epithelization starting from the surrounding skin. Wound healing progress that was unable to be scored was specified as presence of crust materials, presence of fecal contamination, poor image quality, or other.

The alginogel group had 102 feet from 85 cows available for M-score evaluation and 101 feet from 85 cows available for wound healing progress evaluation. The coppergel group had 110 feet from 86 cows available for M-score evaluation and 106 feet from 82 cows available for wound healing progress evaluation. The association of the alginogel or coppergel with M-score improvement and wound healing progress were evaluated using logistic regression analysis and was performed with the statistical software package R.

### Results

The overall M-score improvement between day 0 and day 10 (M-stage change from active to chronic or healed) was 27% for the alginogel group and 94% for the coppergel group, indicating inferiority of the alginogel at changing lesions from active to chronic or healed M-stages.

Of the lesions treated with alginogel, 63% improved between day 0 and day 10, versus 21% of the lesions treated with the coppergel, indicating inferiority of the coppergel with respect to wound healing progression. The majority of the lesions treated with the coppergel could not be assessed (68%), mostly due to the presence of crust materials.

In the final multivariable model, lesions treated with alginogel had a 20-fold decreased odds ratio for M-stage change from active to chronic or healed between day 0 and day 10, compared with lesions treated with coppergel.

With unscorable lesions classified as “improved,” we found no treatment effect on wound healing progress between day 0 and day 10 in the multivariable model. In contrast, with unscorable lesions classified as “not improved,” the wound healing progress between day 0 and day 10 of lesions treated with the alginogel outperformed the coppergel (OR: 2.48; 95% CI: 1.07–5.79).

### Conclusion

Coppergel outperformed alginogel in M-score improvement, resulting in a manageable state of disease, with the majority of lesions remaining in the chronic state. In contrast, the alginogel achieved improved wound healing progress compared with the coppergel. However, none of the products used in our study achieved high cure rates (return to the M0 stage) for active DD lesions.

Preliminary results for the M-score improvement were presented at the European Bovine Congress 2019, 's Hertogenbosch, the Netherlands.

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# **Evaluating the effects of USDA organic approved topical treatments on sole ulcers**

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## Objective

Sole ulcers are caused by a failure of the suspensory apparatus of the third phalanx within the claw horn capsule, and unbalanced weight bearing that leads to contusion and exposure of the underlying corium. Although subclinical lesions may cause little to no discomfort, clinical lesions often result in severe pain and lameness. Clinical sole ulcers require careful corrective trimming and a block applied to the healthy claw. Recovery may be prolonged and result in reduced longevity of animals affected. Management of these cases on U.S. Department of Agriculture (USDA) certified organic dairy operations requires the use of non-antibiotic therapies, most of which have not been evaluated in controlled studies. The purpose of this prospective randomized clinical trial was to determine if the application of non-antibiotic alternatives would improve healing as evidenced by a more rapid re-epithelization of lesions and a decrease in locomotion score for animals with a clinical sole ulcer.

## Materials and methods

One hundred and seventy-three lactating dairy cows with sole ulcer lesions were enrolled between April of 2018 and December of 2020. Treatment outcomes were recorded on D0, 7, 14, 28, 56, and 112 and evaluation criteria included the locomotion score prior to trimming, presence of granulation tissue, and the presence of new epithelium. Enrolled animals were randomized and grouped into one of the five following topical treatments: a) copper sulfate, b) seven percent iodine tincture, c) hydrogen peroxide, d) honey, or e) no treatment. All sole ulcer lesions were lightly wrapped with a bandage following corrective trimming, application of a block to the healthy claw, and the topical treatment (if any) was applied. Treatments were applied on D 0, 7, and 14. Mixed linear models were used for: a) absolute locomotion score at each observation day, and b) change in locomotion score from the previous observation. Full-factorial models of treatment \* day effect were explored. Cox proportional hazards regression for time-to-recovery (defined as days to locomotion score = 1 and no granulation tissue, or else right-censoring on or before D112) also was deployed.

## Results

The results of this study indicate that no antibiotic-alternative treatment group proved either inferior or superior to the control treatment group; that is, corrective trimming and light bandage with no topical treatment. All treatment groups exhibited non-significant differences ( $P>0.10$ ) when comparing treatment outcomes (both locomotion scores and time-to-recovery). There was evidence of immediate locomotion score reduction by D7 for all treatment groups likely associated with application of the block and the removal of weight bearing on the claw with the sole ulcer; however, due to the complex nature of this disease there was prolonged healing and continued reduction in locomotion scores through D 56 and 112 in all groups.

### Conclusions

The outcomes of this study suggest that the time, cost, and effort to use one of the four topical antibiotic-alternative treatments used in this study were unlikely to provide a justifiable return on cost, time and effort invested, or result in improved health and welfare outcomes. This finding is consistent with anecdotal arguments that corrective trimming alone is sufficient for most uncomplicated lesions. In this study for the control group, we elected to wrap the lesion with a light bandage similar to that used for all other treatments in order to control for the impact of a wrap. We cannot specifically comment on if there is any benefit of a wrap compared to no wrap.

# **A novel biomechanically designed orthosis for the bovine claw**

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## Objectives

To develop a novel orthopedic orthosis based on the anatomy and biomechanics of the bovine claw that can be used for claw friendly unloading in the therapy of claw diseases.

## Materials and methods

The orthosis is made of different synthetic materials and has a two-layer structure. It is intended for application to the healthy claw of a limb with a damaged second claw to relieve the latter. It consists of a cushioning layer and a support layer. The hardness of the cushion layer depends on the hardness of the claw horn. In addition, the cushioning layer is extended in the region of the heel to reduce the additional load of the entire weight on the healthy claw. The supporting layer has a reinforcement in the area of the bearing edge, so that at this point the pressure forces are absorbed and transferred by the suspending structures of the claw. The orthosis is rounded at the ends so that it is easier to put on and take off. Attachment to the healthy claw is accomplished by an activatable adhesive that is already applied to the orthotic surface. The adhesive connection is not a fixed barrier layer, but transmits acting forces while maintaining a durable connection.

The pressure distribution between the claw and the orthosis was measured in a compression test device at a load of 200 kg using pressure measurement foils from the TecScan company on 20 cattle distal limbs from the abattoir. The pressure sensors were inserted between the claw and orthosis or block respectively. The pressure distribution was first measured on trimmed claws and then on orthoses and wooden blocks glued with epoxy resin. The measurement data from 3 measurements per setup were then comparatively evaluated and statistically analyzed. The following parameters were considered: Area loaded, magnitude of compressive forces, distribution of compressive forces, peak pressures occurring, correlation between the localization and dimension of the pressure and the anatomical structures located in the claw above.

## Results

In direct comparison to trimmed claws or to wooden blocks, the orthosis achieves a significantly larger surface area (36qcm) for pressure absorption under 200kg load. The absorption surface to trimmed claws (24qcm) is increased by 1.5 times, compared to a glued block (11qcm) by 3 times. The evaluation of data shows that the pressure forces on the sole and the loading of anatomically sensitive regions are significantly lower than with conventional wooden blocks. A considerable portion of the overall pressure is transmitted to the weight bearing edge of the claw. This ensures a physiological load on the claw-bone connection, which suspends the limb skeleton in the horn shoe. On the other hand, the sole and heels are uniformly loaded with low to medium pressure. Pressure peaks, which represent a risk for the development of claw ulcers, were not observed in the pressure measurements with the orthoses.

### Conclusions

The orthosis considers the anatomy and biomechanics of the claw and thus ensures a more claw-friendly pressure load and pressure distribution. In addition, the activation of the adhesive makes the application of the orthoses much easier and also allows a very precise application to the claw, which is crucial for the stability of the blocks and the slip resistance. Our pressure measurement data provide good evidence so far that this is an innovation with great potential to reduce secondary claw damage due to pressure induced lesions and thus improve animal welfare. Evidence will be strengthened in a next step by pressure measurements on larger numbers of live animals.



## **Common household products and novel reversible biocides as antibiotic alternatives for digital dermatitis treatments**

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### Objective

As many producers are moving away from antibiotic treatments, new effective treatments are needed for bacterial infectious diseases of production cattle such as digital dermatitis. Lack of regulation and efficacy testing has led to a plethora of homemade “secret sauces” with little or no scientific backing. A rapid and effective treatment for digital dermatitis is needed. Additionally, effective environmentally friendly disinfectants are needed for decontamination of processing equipment, animal areas, and sometimes workers themselves to maintain biosecurity and diminish disease transmission.

### Methods

The Bioproducts research group has developed a class of broad spectrum, reversible antimicrobials. These compounds at the working concentration are very effective at eliminating bacteria, are safe and non-irritating but when diluted into the environment, break down into inert biodegradable subcomponents. Using standard antimicrobial testing methodology, we evaluated a library of materials hoof trimmers said they have used in treating digital dermatitis, and these novel reversible antimicrobials for effectiveness in preventing growth of several bacterial pathogens of livestock including anaerobes and *Treponema* associated with digital dermatitis, Gram+ and Gram- mastitis causing bacteria and zoonotic agents.

### Results

This work is still ongoing. Many ingredients in homemade sauces have little or no effect, especially when diluted or come in contact with manure. Initial results indicate several of the reversible antimicrobial compounds are effective at inhibiting growth of a wide range of aerobic and anaerobic bacteria at very low working concentrations (less than 0.05% v/v) and still effective in the presence of manure. Some of the candidate compounds were able to completely kill Gram- bacteria with as little as 5 minutes contact time.

### Conclusion/Impacts

Novel reversible antimicrobials do not persist in the environment, are cost effective to use, and highly effective at inhibiting or killing a variety of bacterial species. This class of compounds shows promise to be developed into effective products for livestock producers for the treatment and prevention of bacterial disease.

# **Performance of Swedish claw trimmers regarding shape and dimensions of the trimmed claw**

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## **Objectives**

The aim of the study was to describe the variation in shape and dimensions of the claw after trimming performed by professional Swedish claw trimmers.

## **Materials and methods**

Fourteen professional and certified claw trimmers in Sweden were assessed during their everyday work of preventive claw trimming. For each participating claw trimmer, dimensions were measured of the hind feet on a minimum of eight trimmed cows in the same herd. The selected cows were mainly of Holstein breed and mainly in their first or second lactation. The cows were randomly selected but had to be free from any obvious claw horn lesion. The requirement not to have any claw horn lesion aimed to get a better idea of what the claw trimmer wanted to achieve with his or her routine trimming method and to enable comparisons within and between claw trimmers. The claws were photographed after trimming according to a set protocol. The claw measurements investigated were; toe length (dorsal wall) and toe angle (dorsal wall x ground surface) on lateral (outer) claws, height difference of the posterior part of the lateral (outer) and medial (inner) claw of the same foot, modelling width for both lateral and medial claws as well as sole thickness at the toe area of the lateral claw. and the toe length and toe angle were measured from the digital photos by image analysis using ImageJ Software 1.51j8 (National Institutes of Health, USA). The height difference of the posterior part of the wall between the lateral and medial claws and the width of the modelling were measured using a profile gauge. A portable ultrasound machine (Draminski, iScan2) was used to measure sole thickness in the toe area. The variation in claw shape and dimensions after trimming within cow, within claw trimmer and between claw trimmers were analysed by a residual (restricted) maximum likelihood method and were presented as variance components' percentage of the total variance. The variance components' estimation and descriptive statistics for different claw measurements were performed using Minitab software (version 19.2020.1).

## **Results**

The shape of the claws after trimming were characterized by the following mean measurements: toe length 79.2 mm (SD 5.9; range 63.1-103.5 mm), toe angle 49.7 degrees (SD 3.3; range 38.5-60.7 degrees), sole thickness 9.0 mm (SD 2.2; range 4.6-17.1 mm), height difference between the medial and lateral claw 0.9 mm (SD 3.9; range -12.0 - +16.0 mm), and the mean modeling width given as the proportion of the total width of the claw for the lateral claws was 63.8% (SD 14.4; range 18.1-96.2%) and 70.0% (SD 12.6; range 26.5-91.8%) for the medial claws.

Differences between claw trimmers had the largest impact on the variation seen in sole thickness, which constituted 39.1% of the total variation in that measurement, and the lowest for the measurements of the difference between lateral and medial claw at the posterior part of the claw

(4.4% of the variation of that measurement). Also, differences between cows had a large impact on the variation seen in the sole thickness, which constituted 37.2% of the total variation in that measurement, but differences between cows had also a large impact on the variation seen in toe length, (35.6% of the variation of that measurement). No effect of cow was found for the height difference between the lateral and medial claw or for modelling width. The consistency of trimming within cow was very low considering height difference and width of modelling in lateral claws, indicated by a high percentage of the variation (repeatability variation) of the measures explained by the specific claw trimmer (95.5% and 70.2% of the variation of those measurement, respectively). Moreover, the consistency was also low for toe length and to angle, with 50.4% and 48.7% of the repeatability variation explained by specific trimmer. Best consistency in trimming within cow was found in sole thickness, where the variation explained by specific trimmer was 23.7%.

### Conclusions

The results of the study showed that the professional, certified, Swedish claw trimmer in average performed trimming in line with current recommendations of Swedish functional claw trimming. However, there was a large variation in the repeatability among individual claw trimmers, which cannot be explained by differences between animals. The reasons for the individual inconsistency during claw trimming will be further explored within an ongoing research project aiming to find out which claw trimming method the best practice of claw trimming method in relationship to claw health.

# Evaluation of trimming – Compliance to trimming method

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## Objectives

Most dairy cows receive claw trimming during their productive life. The purpose of preventive claw trimming is to maintain a normal shape and function of the claws and thereby prevent lesions especially claw horn disruption lesions (CHDL) and associated lameness. Over the years several studies have shown positive effect of claw trimming (Manske et al., 2002, Gomez et al., 2013, Stoddard, 2018). Millions of cows are trimmed every day and the cows must take many steps on the outcome of these trimmings. Therefore we need to evaluate the standard of claw trimming to continuously improve claw health. The purpose of this study is to evaluate the result of claw trimming of hind legs.

## Materials and methods

Trimming technique was evaluated on hind legs of 205 cows (29-37 per trimmer) in 6 different herds with 6 different experienced trimmers, trimming according to the White Line Atlas method (White and Daniel, 2017). The evaluations of the trimming were done by 2 trained veterinary master students. Claws with corkscrew, scissor, asymmetry, or other abnormalities were excluded. Two trimmers worked alone, two teams worked exclusively on either the left and right side and in two teams one trimmer trimmed both hind legs.

Trimming was evaluated using direct measurements of five parameters on leg level:

- Balance; same height diagonal zone 3 to zone 1, level sole
- Heel fulcrum; border between zone 2 and zone 3 medial claw
- Heel height; same height across zone 3
- Break over point in the toe correctly assessed, maximum 1/3 of zone 1
- Axial wall which should be perpendicular to the ground, same height across zone 1

All trimmers agreed that the parameters measured for this study were important for the result of claw trimming. Each of the 5 parameters were assessed as compliant with the trimming method or non-compliant with the method by the 2 veterinary students. Inaccuracy in trimming was calculated as the proportion of non-compliant measurements on leg level for each parameter.

## Results

The inaccuracy for balance was between 0-26% for the different trimmers. Differences in inaccuracy for the different trimmers for heel fulcrum 0-94%, for heel height 0-21%, for break over point 0-24% and for axial wall 0-6%. The average inaccuracy across all parameters was 12.5% with a range between 3.4 and 23.1% between trimmers.

There was a significant difference in inaccuracy between left and right legs for 3 of the 6 trimmers. The three trimmers trimmed both hind legs. There was a higher proportion of inaccuracy to right leg compared to left leg with an average difference of 21%.

## Conclusion

There are differences between the claw shape of left and right hind leg following trimming and the difference was more pronounced when both feet were trimmed by one trimmer. Some inaccuracy is expected, and for some of the parameters a difference between left and right leg could have little effect on the cow. However, the difference between trimmers indicate that a lower level of inaccuracy is possible to obtain. The inaccuracies may be explained by trimming but other factors affecting the shape of the claw before trimming cannot be ruled out. The reason could be that the trimmer's position in relation to the foot is the same for both legs or that the protective shield on the grinder is limiting the movements and the compensation for these physical obstacles are inadequate. The effect of the uneven trimming is not yet known. For some of the parameters this may influence the weight load within and between the claws and increase the prevalence of CHDL. The differences between the legs may also be part of the explanation why some herds record more CHDL in one side compared to the other.

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# **The progression of lameness: Temporal connection between first signs of painful hoof disease and apparent lameness**

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## Objectives

The aim of this study was to investigate at what point in time during the development of a hoof disease a resulting lameness would become visible for the human observer.

## Materials and methods

For this purpose, a fortnightly manually observed locomotion score (fLMS) was recorded during one year for 638 milking Simmental cows as a reference for hoof health. These cows lived on 5 farms (2 with an automatic milking system, 3 with a milking parlour) with 162, 117, 180, 92, 87 animals respectively. Additionally, at the exit of every milking parlor or milking robot cameras were installed to observe locomotion score on a daily basis (dLMS) for focus animals. The used scoring system by Grimm and Lorenzini consists out of 3 levels: 1 = sound, 2 = unsound, 3 = lame. Classification is applied in two steps: Firstly, the overall movement of the animal is observed: if the animal presents with asymmetrical gait it is considered “lame” (3). In a second step, animals with symmetrical gait are observed for signs of back arch, compensatory posture while standing and head bob. If any one of the traits is present, the cow is considered “unsound” (2), otherwise “sound” (1).

Animals with fLMS = 3 were examined in a trimming chute and treated within the next day. Animals who were scored “unsound” for three consecutive fLMS, were also examined. If these animals then presented with a hoof lesion or positive reaction to a pain test performed with hoof pincers, their fLMS was corrected from score 2 to 3. To determine the exact day of the onset of visible lameness, meaning LMS = 3, video recordings of these animals were observed daily retrospectively back to the last day where they were observed as “sound” (dLMS = 1).

## Results

During the trial in total 11,753 LMS were recorded, and 243 lameness cases (fLMS = 3) were observed and treated. Video analysis showed that average duration from the last day, when an animal was sound (dLMS = 1) to the onset of visible lameness, was 9.3 days. 52% of the animals with fLMS = 2 presented with an acute hoof lesion or a positive reaction to the pain test when examined in the trimming chute. This means that more than half of the animals who were not acutely lame but only exhibited slightest symptoms of abnormal gait already suffered from pain during locomotion. Half of the remaining 48% developed an acute lameness in the following weeks.

## Conclusions

No comparable study was found in literature about the detailed temporal development of visible lameness in dairy cows. But results from this investigation show that the period in which a hoof lesion manifests as visible lameness is significantly shorter than previously assumed. Up to now

lameness usually is scored during regular hoof trimming once, twice or three times a year, if at all. This interval is, according to our results, far too long to be able to recognize and treat an acute hoof lesion timely and to prevent further damage in the hoof as well as pain for the animal.

Additionally, cows tend to hide signs of pain such as lameness to avoid appearing as potential easy prey. When an acute lameness becomes visible to the observer, the underlying disease that causes this lameness has often already advanced. This was confirmed by the detailed examination of the animals scored  $fLMS = 2$ . Thus, it is very important not to depend only on externally visible measures such as gait traits to evaluate hoof health status in cows. Scoring systems should also measure intrinsic factors signaling painful processes in the animal. These can be detected earlier and with less effort and consequently lead to timely, further pain and cost preventing treatment. A promising approach could be to analyze automatically measured behavioral and performance changes that occur earlier in time during the development of lameness, as was found in the project which this trial was part of.

## **The National Association of Cattle Foot Trimmers: The UK's representative body for professional cattle foot trimmers**

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### Objectives

The National Association of Cattle Foot Trimmers (NACFT) works to increase the credibility and professionalism within the foot trimming industry. Additionally, The Association hosts a range of continuing professional development events with the aim of sharing best practice with its members.

### Materials and methods

NACFT was initiated by a group of trimmers, vets, academics, and other interested professionals in 1997. Since its initiation, the NACFT and its organizational committee have been involved in a wide range of knowledge exchange with both farmers and trimmers alike. These have ranged from the promotion of the "Healthy Feet Programme" (A lameness control programme developed by the Agriculture and Horticulture Development Board (AHDB)) through to the running of an annual UK lameness conference which is open to farmers, trimmers, vets, and anyone interested in cattle mobility. The NACFT now has approximately 150 trimmers listed as members on its website from across the UK with a range of affiliate members (from aligned professions mostly) also listed. Throughout this, the key goal has been to promote the positive welfare of dairy cattle, the improvement of the UK dairy herd's lameness status, and to ensure all trimmers are working to a high and safe standard.

### Results

The NACFT works with a range of organizations including the British Cattle Veterinary Association (BCVA), the Agriculture and Horticulture Development Board (AHDB) and other bodies to ensure that trimmers are represented at meetings discussing principles and legislation surrounding cattle foot health. In the past 12 months, The NACFT has begun to run its own "continuing professional development" (CPD) days which are open to its members where current best practice is disseminated with regards to animal handling, lameness control and professionalism (among many other topics). The aim is to run a number of these days across the UK throughout the year to promote best practice throughout our membership.

Furthermore, the NACFT is working to collaborate further; this is with respect to both groups it currently works with and those with whom new links are being drawn. Within this collaboration, the NACFT hopes to not only represent the trimmer in important discussions occurring at a national herd level, but also improve the mobility of dairy cattle throughout the UK.

### Conclusions

Through collaboration and promotion of best standard practices, the NACFT works to promote the improvement of the UK dairy herd's mobility. Working with other industry bodies and individuals is key to ensure consistent dissemination of best practice lameness management is being disseminated.



# Effect of hoof bath formulations on manure digester methanogenic bacteria

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## Objectives

Foot bath formulations that are used for the prevention of hoof diseases are typically discarded in the manure pit after use. It has previously been demonstrated that copper sulphate has a negative effect on digester performance. Therefore, it is important to evaluate the effect of foot bath formulations on a manure digester. Manure digesters use methanogenic bacteria for the production of biogas. The goal of this study was to investigate the effect of two-foot bath products (Intra Hoof-fit Bath and Intra Eco-Bath) on the growth rate of methanogenic bacteria.

## Materials and methods

Experiments were performed by Opure BV (Ede, The Netherlands). Test concentrations were calculated based on worst-case practical conditions (i.e., a small digester and long retention time). A weekly 200-liter hoof bath with 5% product solution would then result in a product concentration inside a digester of 60 mg/l. Therefore, product concentrations of 10, 20, 50, 100 and 250 mg/l were evaluated.

Methanogenic bacteria were grown in anaerobic reactors with acetic acid as the main substrate at 35°C. Bacteria were incubated for 5 days at low substrate levels in the presence or absence of product concentrations. The amount of produced methane was measured to calculate the Chemical Oxygen Demand (COD) and reactor feed COD was adjusted daily to compensate.

After 5 days, the bacteria were sieved and maximum methanogenic activity was assessed at high substrate levels. Dry matter content (gram/l) and % Volatile Suspended Solids (VSS) of the sieved bacteria were determined. 10 g of methanogenic bacteria were added to a new reactor. At start and after 7 hours the reactor pressure and methane concentration of produced biogas was measured. Maximum methane production rate was calculated using the formula (total ml of CH<sub>4</sub> formed (at 0°C, 1 atm) x 2.85 (conversion of CH<sub>4</sub> into COD)/((7h/24h) x 10 g bacteria x x g dry matter x % VSS content)) = kg COD/kg VSS/d.

Deviations from control of max. 5% were not considered as inhibition.

## Results

The average activity of the first control was 1.13 COD/kg VSS/d. Methane production activity after incubation with 10 to 250 mg/l Intra Eco Bath ranged from 1.07 to 1.15, which is 95 to 102% of control. The average activity of the second control was 1.17 kg COD/kg VSS/d. The activity after incubation with 10 to 250 mg/l Intra Hoof-fit Bath ranged from 1.11 to 1.22, which is 95 to 105% of control. All deviations fell within the specified 5% range, reflecting no inhibition of methanogenic bacteria.

### Conclusions

The foot bath products did not inhibit methanogenic bacteria up to 250 mg/l. Since it is very unlikely that a digester would reach a product concentration above 100 mg/l, both products are safe to use on farms with a biogas manure digester.

## **Foot injuries and postural disorders in beef cattle in Brazil: Practical treatment perspectives**

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Brazil has an estimated 220 million-head bovine herd of which 90% are beef cattle, predominantly Zebu breeds. Eighty percent of the production stages take place in grazing. Twenty percent of the 44 million cattle slaughtered annually come from feedlots and 15% of the 100 million breeding cows receive artificial insemination. So, there is a great demand for young bulls for natural breeding and many breeders are dedicated to genetic improvement. Thus, in Brazil we have 2 types of livestock activity, a beef production chain (breeding, rebreeding and fattening) and a young bulls production chain to meet the great market demand. The meat production chain animals are managed on pasture and only receive concentrated supplementation in the finishing phase, so they are medium-sized animals. Young animals still in development gain less than 1.10 pounds/day (500g/day) and are weaned at 551 pounds (250kg). The locomotor system is not overloaded and posture disorders are not a problem.

The main cause of lameness in animals in the meat production chain are foot lesions – predominantly chronic pododermatitis, interdigital hyperplasia and its complications, chronic injuries (gabarro) and paradigits pododermatitis, and heel ulcers. Laminitis-related injuries, such as subsolar abscess, white line disease, toe ulcer, and chronic laminitis, also occur in termination confinements. These animals are assisted less by trimmers and animals with locomotor dysfunctions are slaughtered.

In the bull production chain, the animals receive concentrated supplementation from birth, so they are high-weight animals, greater than 1.10 pounds/day (500g/day), reaching up to 4.40 pounds/day (2kg/day) and 992 pounds (450 kg) at 8 months, when adults have high volume and body weight, reaching 2,866 pounds (1,300 kg) or more and that overloads the locomotor system. The main disorders of the locomotor system found are posture disorders, predominantly in young animals up to 16 months old. The main cause of lameness is also foot pododermatitis: interdigital hyperplasia, chronic pododermatitis, interdigital phlegmom, and heel ulcers. Sodomy is a major cause of heel ulcers in young males. In adult animals with large volume and body weight, we also found vertical fissure, axial fissure and white line disease. This group of animals has higher added value and is assisted more by trimmers.

Foot pododermatitis is treated surgically and postoperatively, using “Long Time Hoof Bandage” (LTHB) that lasts 30 to 60 days or more and orthopedic braces when necessary. Early identification and intervention improve the prognosis of treatments and LTHB contributes to the strategic control of chronic pododermatitis.

The main disorders of posture, causing the disposal of young animals, are “bow legs” and “out fetlock.” Animals with such disorders are not marketed for breeding purposes and this causes great damage to the breeder, since they are animals with a high production cost, added economic

value, due to large investments in artificial insemination and in vitro fertilization. These animals are destined for slaughter.

The high prevalence of bow legs and out fetlock has been a cause of great concern for breeders. The occurrence of these disorders has increased in the last 10 years. These disorders are frequently found in 50% of male and female animals at weaning (7 to 9 months of age), and 30% in animals at 16 months of age. These disorders occur during the animals' growth phase and up to 16 months of age when the posture is defined. Little or no randomized scientific research on the subject has been carried out to date.

The etiology appears to be related to three factors: genetics, as the prevalence appears to be higher in some families; high weight, as the prevalence is very low in groups of animals weighing less than 500g/day; and occurrence of laminitis episodes during the osteogenesis phase, corresponding with clinical signs, such as sole hemorrhages and wall stress lines, are often found in groups of animals with high prevalence.

Bow legs is a disorder seen in the forelimbs of animals, seen from the front, at the level of the carpus, and also found less frequently at the level of the radio-ulnar humerus joint.

Out fetlocks can be seen in both forelimbs and hindlimbs; thus, it can be seen from the front or from behind.

Clinical signs are the same for both pathologies and each animal responds differently.

The first clinical signs, which we call "first stage," can be evidenced at 3 to 4 months of age by the incorrect support of the paw to the ground. The limbs are parallel and aligned – as if there was sensitivity on the soles of the medial hoof nails and the animal adopted a defensive posture.

In the "second stage," we observed a subtle deformity of the lateral hoof nails. The limbs remain aligned and parallel.

In the third stage, nail deformity and mild osteo-articular deviation are observed. In the "fourth stage," there is a severe deformity of the nails, also osteo-articular.

The success of corrective treatment depends on early identification and intervention in the first and second stages, if the prognosis is good and the animals respond to corrective clipping technique. In the third stage, if the prognosis is reserved, the animals do not respond to simple clipping techniques. A positive response was observed using shoeing techniques. There is stabilization of the condition and even reversal in many cases.

In the fourth stage, if the prognosis is poor, no therapeutic responses were observed through clipping or shoeing techniques.

The functional clipping of nails at 7 and 12 months of age seems to contribute to reducing the occurrence of postural disorders in cattle in Brazil.