# USING COMMERCIAL PEDOMETER DATA TO PREDICT THE OCCURRENCE OF HOOF LESIONS

REPORT OF A SHORT TERM SCIENTIFIC MISSION (STSM) OF COST ACTION FA1308
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## PARTNERS

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The work will be carried out at Natural Resources Institute Finland (Luke) in Finland in collaboration with Aarhus University, ILVO and IceRobotics. The involved senior researchers and data analysts in the different institutions are:


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Duration: 7 March 2016 – 16 April 2016 (41 days). The STSM has been carried out as planned, with first a kick-off meeting in Denmark and then execution of the work in Finland.

## BACKGROUND

Lameness in dairy cows is a modification of the gait and the clinical manifestation of painful disorders mainly related to the claws. Not only is lameness a major problem to the health and welfare of the affected animals, lameness is also one of the most expensive health disorders for the dairy farmer, with a cost only preceded by reduced fertility and mastitis (Enting et al., 1997).

Lameness itself is a symptom, not a disease, and can be caused by several different diseases that have different aetiology, such as digital dermatitis, interdigital dermatitis and interdigital necrobacillosis, and the non-infectious claw horn disruption diseases like sole ulcer and white line disease (Bicalho and Oikonomou, 2013). Other causes for lameness are joint diseases, traumatic leg injuries, and neurological problems. Sole ulcer and white line disease included 65 % of the lesions diagnosed in lame cows (Bicalho and Oikonomou, 2013). However, not all cows with claw lesions are lame, and not all lame cows have a claw lesion, thus increasing the difficulty of screening farms for the main lameness cause. To explain the discrepancy between lameness and presence of claw lesions, it has been suggested, that 1) the type of lesion seems to play an important role in the relationship between hoof lesion and lameness; 2) some lesions take time to develop, such that not all lame cows will show visible lesions at the moment of screening; and 3) the degree of lameness is more related to the severity of the lesion than to the lesion size (Van Nuffel, 2014).

With increasing farm size, time to observe and monitor the individual cows decreases and hence, also proper lameness management is impaired. Thus, there is a need for tools to support farmers in detecting lame cows in need for treatment. Pedometers are already available in many commercial

farms and lameness has been shown to have an effect on the lying time of dairy cows (Ito et al., 2010). However we know very little about the relation between lying time and hoof lesions and which changes the lesions cause in the lying behaviour of individual cows.

## AIM OF THE STSM

The aim of the STSM was to develop a model to predict hoof lesions based on data from commercial pedometers (IceTag-sensors). The data used for modeling had already been collected. The work carried out during the STSM involves data analysis and publishing the results.

## KICK OFF MEETING

At the kick-off meeting the existing dataset was discussed, which contained continuously measured lying behavior of approximately 400 cows from four Danish commercial farms using IceTag-sensors (IceRobotics, Edinburgh, UK). Results on the relationship between the data from the accelerometers and the occurrence of lameness were published before (Thorup et al., 2015). At the kick-off meeting the possibilities and expectations for the STSM were further discussed. It was concluded that the dataset could potentially be used for:

- Estimating the effect of lactation stage on the lying behavior (possibly for a short communication)
- Estimating the relationship between lying time and hoof lesions for different types of lesions and how this develops over time
- Designing detection algorithms to predict hoof lesions for individual cows

During the kick-off meeting the categorization of hoof lesions was also discussed with veterinarian and expert Peter Thomsen (Aarhus University), who was involved in the data collection. Especially for the on-farm detection of hoof lesions it would be important to only alert the hoof lesions that need (urgent) treatment by the farmer. Therefore, a first categorization was agreed upon with 3 categories: (1) cows with no (significant) lesions; (2) cows with mild lesions for which no urgent action is needed (regular hoof trimming should be sufficient); (3) cows with painful or severe lesions that would need urgent treatment.

## DATASET

The existing dataset contained continuously measured lying behavior of approximately 400 cows from four Danish commercial farms in 2008 and 2009 using IceTag-sensors (IceRobotics, Edinburgh, UK) (Thorup et al., 2015). Ten accelerometer variables were available:

- Number of walking bouts and number of standing bouts [bouts/day]
- Number of steps during walking and number of steps during standing [steps/day]
- Duration of lying, walking and standing [s/day]
- Motion index during lying, walking and standing [g/day]

Furthermore, the dataset included the locomotion score every second month; including scoring immediately before hoof trimming.

In addition, data from hoof trimming was collected three times/year/farm by two scientists with a veterinarian background. The lesions were scored using the Nordic system for scoring hoof lesions

(Thomsen et al., 2008). The system includes the type, location and severity of lesions. A first task during this STSM was to merge the lesion scorings with the dataset of the accelerometer and lameness data. This was done using R 3.2.3 (R Core Team, Vienna, Austria). Some erroneous data were removed (double scorings of the same cow on the same or consecutive days) and the overall lesion score was calculated (using the categorization discussed during the kick-off meeting).

Data of milk yield was also available, but only data of two out of the four farms could be matched with the other measurements. Milk yield was thus available for only around 20% of the measurement days, so after a short initial analysis, it was decided not to include milk yield in the results. In the dataset some very long lactations were found, as well as missing lactation numbers (parity) in some cows. Therefore, the birth dates, calving dates and lactation numbers were extracted from the Danish national herd database for all cows in the study and missed calving dates were repaired.

This resulted in a new dataset which now also included the following hoof lesion scorings:

- Sole hemorrhages
- Sole ulcers
- White line hemorrhages
- Digital dermatitis (score and size)
- Interdigital dermatitis
- Heel horn erosion
- Interdigital hyperplasia
- Double sole
- White line disease
- Interdigital phlegmone

## RESULTS

### EFFECT OF LACTATION STAGE ON LYING BEHAVIOR

Several authors have already reported that lying time increases with increased days in milk (Bewley et al., 2010; Vasseur et al., 2012, Solano et al., 2016). However, these results are based on short measurement durations (four to ten days of measurement) and the comparison of two or three stages of lactation (mid – early – late or early – late). No time series or lactation curves for lying time have been found. This information is very important to know, however, to see how the lying time and other behaviors change with changing days in milk and to be able to quantify normal lying behavior in more detail.

From the dataset, all 365 lactating cows with more than 30 days of data up till 305 days in milk (DIM) were extracted and the accelerometer variables were averaged across these cows per DIM. The advantage of this dataset is that longer time series of individual cows are available, with on average 176 data points per DIM and 115 data points per cow. The results are very interesting and will be submitted as a short communication to The Veterinary Journal. At the end of the STSM period, a first draft of this paper is with the co-authors for revision and submission is expected within weeks.

### RELATIONSHIP BETWEEN LYING TIME AND HOOF LESIONS

The relationship between lying time and lameness has been investigated already by several researchers (Ito et al., 2010; Thorup et al., 2015; Solano et al., 2016). In contrast, much less information

is available on the relationship between lying time and hoof lesions. As many types of lesions exist and grouping of lesions is not straightforward and often a point of discussion, a large dataset is needed for this purpose. The dataset used in the STSM contains over 300 lesion scores. Still, grouping or ranking of lesions is needed as cows most often have multiple lesions at the same time. During the STSM, the analysis described below was performed for two different groupings of lesions to see if the grouping influences the results and what reasoning can be found for the most suitable grouping to be used. If possible, cows having two severe types of lesions were identified as a separate group (for example cows having severe digital dermatitis and sole ulcers).

During the STSM the daily lying time during the week before trimming (which coincided with scoring) was compared for cows with different types and severities of lesions. Some interesting effects of certain types of lesions were found. In addition, the timing of change was studied by comparing, per type of lesion or group of lesions, the weekly average lying time of up to 14 weeks before trimming and 11 weeks after trimming with the values at the week before trimming (when the lesions is assumed to be in the stage recorded at scoring). The same analyses were repeated for the other accelerometer variables. A large part of the results have already been generated, but the work will continue after the end of the STSM (fine-tuning the results and writing). These results will lead to a scientific publication and all involved researchers are dedication to continue this work as a joint effort also after the end of the STSM.

## DETECTION ALGORITHMS FOR HOOF LESIONS

A third aim of the STSM was to develop a validated model to predict hoof lesions based on pedometers. For this purpose, time series of the lying behavior of all individual cows were made and visually inspected, including the overall lesion score, the occurrence of sole ulcers and digital dermatitis and the lameness score. A major challenge in developing this model is that the lesions were only recorded at some discrete time points (on average 2-3 times per cow) and that the overall health status of the cows is not known. Looking at the individual cow plots, day-to-day variability was very large. The approach was taken to first explore the effect of lactation stage and hoof lesions on the lying time, since these results are the first steps towards a potential detection.

## OTHER RESULTS

The mission promotes collaboration and exchange of ideas and skills between four countries and five institutions. Another STSM exchange has started in the meanwhile from Luke to ILVO (Lilli Frondelius). Four of the involved researchers are also closely collaborating for the organization of the first DairyCare training school at ILVO: “The application of sensors for lameness and behaviour research in ruminants”. Results of this STSM will be presented at this training school and at future DairyCare conferences. In addition, the involved institutes have already investigated opportunities for submitting project proposals in topics on Precision Livestock Farming, so the collaboration is expected to continue also in the future.

The applicant has broadened her knowledge on dairy (housing, lameness, hoof lesions, lying behavior), sensor technologies (IceTags, but also indoor localization systems) and data analysis techniques (modelling, statistics), as well as increased her network through this STSM. Also working with R is a skill that was newly acquired during the STSM. This STSM will be of high value for her further career as a (junior) researcher.

## ACKNOWLEDGEMENTS

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