THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Section 7- Guidelines for Claw Health Traits in Bovine

Section 7 – Bovine Functional Traits

Version May, 2022

Network. Guidelines. Certification.

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Change Summary

Date of Change	Nature of Change
August 2017	Reformatted using new template.
August 2017	Table of contents added.
August 2017	Heading numbers and heading text edited for clarity and removal of redundant text.

August 2017	Insert links to ICAR website for Claw Health Atlas and Disease Codes.
August 2017	Insert table and equation captions. Insert Table and Equation index into Table of Contents.
August 2017	Fixed bulleted lists; fixed et al as italics and minor changes.
August 2017	Stopped Track changes and accept all previous changes otherwise there was no valid pagination.
August 2017	Added two Sections female fertility in dairy cattle and udder health (Section 7.2 and 7.3). Add index of figures to Table of Contents. V17.05.
August 2017	Added figure and header on page 64.
August 2017	Accepted all changes. V17.06.
August 2017	Stopped Track change sand accepted all previous changes.
August 2017	Moved the file to the new template (v2017_08_29).
August 2017	Correct heading error on page 72 and some other minor edits.
October 2017	Hyperlinks have been corrected.
April 2018	Minor corrections proposed by Dorota Krencik.
April 2018	The "Table of content" for the Figures has been updated as indicated by Dorota Krencik.
January 2018	Claw Health chapter (4) added.
May 2018	Claw Health chapter (4) replaced with new version. Edits marked with track changes. All changes accepted to facilitate final edits and cross referencing.
June 2018	Minor corrections as suggested by Noureddine Charfeddine and Christa Egger-Danner.
July 2018	Draft approved by ICAR Board on 24th July.
August 2018	File name added to improve version control. Draft finalised for distribution to General Assembly for approval.
October 2018	Accepted all previous changes and stopped tracking; paginated according to the template. Published on ICAR website.
April 2019	Lameness chapter (5) added.
October 2019	Lameness chapter 5 updated by FT-WG.
January 2020	Edits made by the FT-WG. Submitted to ICAR Board for approval.
March 2020	Corrections by Anne-Marie Christen (CA) and by Johann Kofler.
April 2020	Corrections by Dorota Krencik as indicated in her email (31-March 2020).

May 2022	Adding chapter of Calving traits to guidelines.

1 Claw Health in Dairy Cattle

1.1 Introduction

Claw and foot disorders have become a major concern of dairy farmers around the world. They are among the major culling reasons in dairy cattle and play a significant role for the profitability of farms. Compromised animal welfare is caused by their high incidence, severity and repetitive occurrence.

Different data sources related to claw and foot disorders are available, including data from veterinarians, claw trimmers and farmers. The recording of claw health data during regular claw trimming has been identified as a particularly valuable source of information for herd claw health management and for genetic evaluation. However, integration of data for monitoring and improving dairy health should be carefully considered.

Nordic countries have pioneered the recording of claw health from claw trimming visits and then systematically using the data. Routine documentation of claw health data started in Sweden in 2003 and one year later in Finland and Norway (Johansson *et al.* 2011, Ødegård *et al.* 2013, Häggman and Juga 2013). Since 2006 claw health data has been routinely recorded in the Netherlands. In several countries it is now possible to electronically register data from claw trimming visits and recording systems and consequently accessibility of claw data have improved. Electronic systems by professional trimmers to document claw health status are,for example, used in Denmark, Finland, Sweden, Norway, Canada, France, Germany, and Spain (Kofler, 2013). With this development, larger amounts of claw health data are becoming available, implying the need for harmonization and further measures to strengthen data quality and consistency.

The ICAR Claw Health Atlas was published in 2015 (Egger-Danner *et al.* 2015) and has so far been translated to nineteen languages. The aim of this atlas was to harmonise the collection of high quality data within and across countries.

The purpose of these ICAR guidelines is to give recommendations on recording, data validation and use of claw health information, with focus mainly on claw trimming data.

1.2 Definitions and Terminology

1.2.1 Sources of data related to claw health

A description of each of the types of data related to claw health is provided in Table 1.

Table 1. Types of data related to claw health.

No.	Type of data	Description
1	Claw Trimming Data	Several studies have shown that data recorded by hoof trimmers are suitable for genetic evaluation of claw health (Häggman and Juga 2013; Koenig et al. 2005; van Pelt 2015). Claw disorders are included in the comprehensive ICAR Central Health Key, that is consistent with the ICAR Standard for claw data recording and the ICAR Claw Health Atlas (see appendix of the ICAR Health guidelines). These standards should be referred to in electronic systems supposed to facilitate data recording in connection with claw trimming. The high coverage and regular structure of the claw trimming data make them highly valuable for analyses, and these guidelines will focus on that source of information on claw health.
2	Veterinary Diagnoses	In addition to information from claw trimming, veterinary diagnoses are an additional source of information that is informative especially for more severe cases. This information is available in countries with routine recording of diagnoses, often directly in connection with veterinary interventions and medical treatments, including the Nordic countries, Austria, and Germany (Aamand, 2006; Egger-Danner et al., 2012; Østerås et al., 2007). Analyses of claw disorders exclusively based on veterinary diagnoses are expected to have much lower frequencies than those based on hoof trimming data and may include only diseases found in lame cows. Integrated use of data, including records from regular preventive trimming, will accordingly give a more complete picture of the claw health status of the herd. More information on the collection and use of health data is available in chapter 1 ( ).

No.	Type of data	Description
3	Lameness and locomotion scoring	Lameness describes irregularity of locomotion and can have very different causes. However, in most cases it can be seen as a sign (symptom) of a painful condition in the locomotor system and more specifically in the limbs. This implies that the results of lameness examinations (which is the distinction between lame and non-lame animals) and data from locomotion scoring (e.g. 9-point scale used for conformation scoring – refer to Section 5 of ICAR Guidelines); 5-point-scale such as the system described by Sprecher et al., 1997) could be useful as indicators in analyses focused on claw health. There are alternative systems to be applied according to intended users and use (e.g. Sprecher et al., 1997; Flower and Weary, 2006). Several studies have shown that the results from screening of locomotion can be used for supporting and improving herd management and breeding (Berry et al., 2010; Gaddis et al., 2014; Koeck et al., 2014). Although the causes of lameness or disturbed locomotion remain unclear and limits the value of working exclusively with indicator traits alone, they may become obvious when referring to incidences of individual claw health traits as measures of success. Therefore, the use of information on whether or not an animal showed clinical signs of pain and the severity can be very valuable. The results from Egger-Danner et al. (2017) indicate that this information could be used for breeding purposes despite the fact that lameness scores do not identify the causes of lameness. Locomotion and lameness data are integral parts of recording systems for routine welfare assessments on farms, so increasing coverage may be expected for the future. The increased amount of data may at least partly outweigh the shortcomings of scoring systems regarding detection of early and mild cases with slightly impaired locomotion (Tomlinson et al., 2006; Tadich et al., 2010; Bilcalho and Oikonomou, 2013).
4	Feet and Legs conformation traits	Type traits associated with feet and legs are included as part of the conformation assessment of breed societies and dairy cattle breeding organisations and as such are also covered by Section 5 of the ICAR guidelines. Data from this routine and internationally harmonized way of collecting data may be considered as source of additional information for claw health improvement. Studies in different countries and breeds have revealed conflicting results regarding the correlations between conformation of feet and legs on the one hand and claw health on the other hand: There are only a few reports showing favourable correlations (Fuerst-Waltl et al., 2015; van der Linde et al., 2010) while most studies have weak correlations and consequently limits the use of conformation traits as indicators (e.g., Koenig and Swalve, 2006; Häggman and Juga, 2013; Ødegård et al., 2014). However, locomotion assessment is an exception and showed more consistent results and moderate correlations, although scored only in non-lame cows and usually only once in first parity cows.

No.	Type of data	Description
5	Data from Automation	Different systems are becoming available for automated recording of data on activity, locomotion pattern, lying and feeding behaviour of cattle, including pedometers, video image analysis, thermography and other sensors. Although the focus of their use is often oestrus detection, these measurements can provide useful information for early and more accurate detection of lameness and foot pathologies (Alsaaod et al., 2015; Beer et al., 2016; Nechanitzky et al., 2016). Experiences with broader use of this type of data, which is becoming increasingly abundant is still limited; but parameters such as number and duration of lying bouts, number and length of strides, walking speed, bite rate while grazing, duration and pattern of feed intake and rumination have been shown to be different between healthy and sick cows (Beer et al., 2016). Their potential to help identify animals that require special health care within farms is likely to be increasingly exploited, and routines for using automated data across herds in the context of claw health improvement are expected.

1.2.2 Definitions of claw health disorders according ICAR Claw Health Key

To be able to combine and compare claw health data between countries and for breeding purposes, standardizing the recording and harmonizing the terminology of claw disorders are crucial. Harmonized definitions have been published by the ICAR WGFT (Egger-Danner *et al.*, 2015). The Atlas describes 27 claw disorders (Table 2); the corresponding ICAR Claw Health Atlas illustrates the distinct disorders by typical pictures in a number of languages.

Table 2. Abbreviations and harmonized descriptions of foot and claw disorders (Egger-Danner et al., 2015).

Name	Code	Description	Synonymous Terms
Asymmetric claws	AC	Significant difference in width, height and/or length between outer and inner claw which cannot be balanced by trimming	–
Corkscrew claw	CC	Any torsion of either the outer or inner claw. The dorsal edge of the wall deviates from a straight line	–
Concave dorsal wall	CD	Concave shape of the dorsal wall	–
Digital dermatitis	DD	Infection of the digital and/or interdigital skin with erosion, mostly painful ulcerations and/or chronic hyperkeratosis/proliferation	Mortellaro disease, Strawberry disease
Interdigital/	ID	All kind of mild dermatitis around the claws that is not classified as digital dermatitis.	–

Name	Code	Description	Synonymous Terms
superficial dermatitis			
Double sole	DS	Two or more layers of under-run sole horn	Underrun sole
Heel horn erosion	HHE	Erosion of the bulbs, in severe cases typically V-shaped, possibly extending to the corium	Slurry heel, Erosio ungulae
Horn fissure	HF	Crack in the claw wall	–
Axial horn fissure	HFA	Vertical (longitudinal) crack in the inner claw wall	–
Horizontal horn fissure	HFH	Horizontal crack in the claw wall	–
Vertical horn fissure	HFV	Vertical (longitudinal) crack in the outer or dorsal claw wall	–
Interdigital hyperplasia	IH	Interdigital growth of fibrous tissue	Corns, Tyloma, Interdigital fibroma
Interdigital phlegmon	IP	Symmetric painful swelling of the foot commonly accompanied with odorous smell with sudden onset of lameness	Foot rot, Foul in the foot, Interdigital necrobacillosis
Scissor claws	SC	Tip of toes crossing each other	–
Sole hemorrhage	SH	Diffused and/or circumscribed red or yellow discoloration of the sole and/or white line	Sole bruising
Sole hemorrhage diffused form	SHD	Diffused light red to yellowish discoloration	–
Sole hemorrhage circumscribed form	SHC	Clear differentiation between discoloured and normal coloured horn	–
Swelling of coronet and/or bulb	SW	Uni- or bilateral swelling of tissue above horn capsule, which may be caused by different conditions	–
Ulcer	U	Ulceration of the sole area specified according to localization (zones) such as bulb ulcer, sole ulcer, toe ulcer/necrosis	–
Sole ulcer	SU	Penetration through the sole horn exposing fresh or necrotic corium.	–

Name	Code	Description	Synonymous Terms
Bulb ulcer	BU	Ulcer located at the bulb	Heel ulcer
Toe ulcer	TU	Ulcer located at the toe	–
Toe necrosis	TN	Necrosis of the tip of the toe with affection of bone tissue	–
Thin sole	TS	Sole horn yields (feels spongy) when finger pressure is applied	–
White line disease	WL	Separation of the white line with or without purulent exudation	–
White line abscess	WLA	Necro-purulent inflammation of the corium	–
White line fissure	WLF	Separation of the white line which remains after balancing both soles	–

The most common classification of claw disorders makes the distinction between infectious and non-infectious disorders (Alsaood *et al.*, 2015). Infectious disorders are primarily digital dermatitis, interdigital dermatitis, interdigital phlegmon, and heel horn erosion. Non-infectious disorders include claw horn disruptions (also called claw horn disorders), sole hemorrhages, white line fissure, horn fissures, ulcers, thin sole, and all kinds of claw distortion. However, several disorders that affect the claw horn capsule, such as wall, sole, and its junction, i.e. white line, are often secondarily infected. This also applies to interdigital hyperplasia which is usually considered to be non-infectious, too, although pathogenesis is still partly unknown.

1.2.3 Definitions of other terms used in these guidelines

Definitions of Terms used in these guidelines are given in Table 3.

Table 3. Definitions of terms used in these guidelines (detailed information is found in chapters 0 and 1.6).

Term	Definition
New lesion	A claw disorder recorded for the first time in a particular location or claw or recoded later than the minimum recovery period after the previous recording of the same kind in the same location or claw.
Chronic cow and persistent lesion	A chronic cow is a cow presenting a persistent lesion over a prolonged period and/or several relapses such that shows the same disorder after 3 consecutive trimmings during lactation, with intervals in between exceeding the period of time previously established and required to define a new lesion.

Term	Definition
Incidence rate	The proportion of cows developing at least one new case of a claw disorder relative to all cows screened for claw disorders with comparable density in a certain period of time (e.g. annual incidence rate).
Prevalence rate	The proportion of cows affected by a particular claw disorder relative to all cows screened for claw disorders in a certain period of time or at a certain point of time (e.g. annual prevalence rate, trimming visit prevalence rate).
Cows at risk	Cows screened for presence of claw disorders, so cows presented for trimming at a particular date or cows present in the herd and included in regular checking of claws.
Time period at risk	Time frame defined for benchmarks (e.g. year, season or lactation period).
Reference levels	Figure defined for benchmarking which specification by, e.g. herd size, production level, geographic location, flooring, housing systems, trimming policy, season, parity, age and stage of lactation.

1.3 Scope

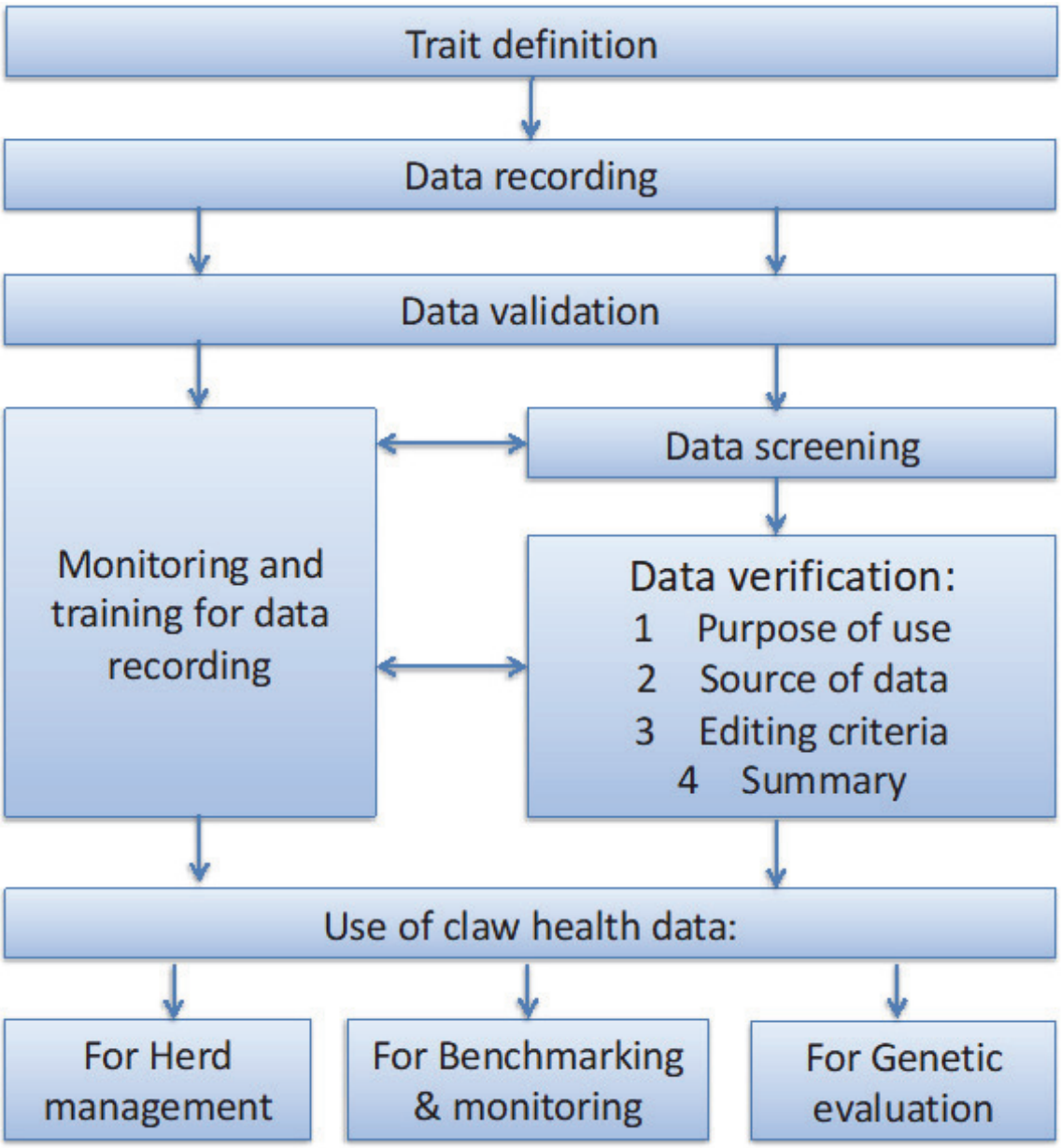

Figure 1. Overview of scope of guideline for claw trimming data. Each box is further elaborated in the chapters below.

Figure 1 gives a summary of the main elements of this guideline. The current guidelines on claw health cover only data recorded by hoof trimmer.

1.4 Trait definition - claw trimming data

More detailed information is available under Egger-Danner *et al.* 2015, Christen *et al.* 2015 and here on the ICAR website.

1.4.1 Definition - claw trimming data

At trimming the claw health status of each cow is recorded. Cows with no claw disorder should be recorded as healthy, and presence of any defined claw disorder (Table 2) should be recorded at animal, leg or claw level.

The number of records and the level of specific details used vary between recording systems (see codes Table 2). Traits can be defined more in detail if additional information on location (e.g leg/claw/position) and severity is recorded (refer chapter 1.5 - Data Recording – claw trimming data).

1.4.2 New lesion

For a specific disorder, the differentiation between a new episode, or a new lesion and a previous case requires a definition of the recovery period of each lesion (if possible). For some disorders (AC CC CD and SC) the process is permanent or irreversible, so no healing period can be defined. For other claw disorders a recovery period of 4 months can be used, i.e. **if a new case is recorded more than 4 months after the previous case it can be assumed to be a new lesion.** On the other hand, the development of the same lesion (e.g. WLD) on **another location** (claw) is considered to be a **new lesion**.

1.4.3 Chronic cow and persistent lesion

A chronic cow is a cow which shows a persistent lesion over a long period and/or shows various relapses during lactation. It could be due to a failed treatment or to a delay in recognition. In order to differentiate an acute lesion from a chronic one, it is important to know the period of time that has passed since it first appeared, or the number of relapses recorded for the same lesion. This is a key concept when it comes to make decisions about individual cow in terms of herd management. **A chronic claw health lesion is defined as a lesion which persists over 3 consecutive trimmings during lactation, with intervals in between exceeding the period of time previously established and required to define a new lesion.**

1.5 Data Recording – claw trimming data

The conditions and circumstances of claw health management differ widely across countries (Christen *et al.* 2015). The percentage of trimmings recorded by professional trimmers varies. Claw care is generally carried out by trained farm staff, professional claw trimmers, or the farmers themselves. Different tools are used to record information on claw disorders and foot and leg conditions, including individual free-text notes (no standardized form), standard forms with reference to the key for claw health on paper sheet reports, free-text or standard forms on mobile electronic devices, and herd management software. For use in routine genetic evaluations for claw health, data from claw trimming need to be recorded routinely and stored in a central database. For advanced herd management tools with benchmarking and comparison between farms, central data storage is necessary as well. A key aspect of the successful initiatives to build routine genetic evaluations for claw and leg health is the development of an infrastructure for electronic documentation and recording of claw trimming data (Kofler *et al.*, 2011, 2013; Nielsen, 2014; Van Pelt, 2015). Data security aspects have to be given special attention and measures have to be implemented around the transparency of use of data and protection of personnel.

Minimum requirements:

a. Animal-ID
b. Herd-ID
c. Records on animal level
d. Date of trimming

Highly recommended:

a. Trimmer-ID (it is essential for data validation but also very valuable for the use of the data)

Optional/additional information:

a. Recording the location of the disorder/lesion: leg (e.g. left front leg), claw (inner or outer claw), positions (claw zones (Kofler *et al.* 2011))

b. Recording of severity degree: e.g. mild, severe, M-stages for DD (Dopfer, 2009).

1.6 Data Validation

The validation of data is based on a comparison between collected data and valid references to ensure that data is compliant with standards and fit for the intended use. The challenge with the validation process is to choose appropriate criteria and adequate levels in order to extract reliable information from raw data. There are two main steps in the data validation process: data screening and data verification.

1.6.1 Data Screening

Data screening consists of a series of basic checks on integrity, format and completeness. For instance, checks can be made on ID plausibility for animals, herds and diagnosis codes, which are necessary to avoid suspect values. Other checks can be on the plausibility of dates, verifying dates of birth, calving and diagnosis in order to eliminate typing errors. Data screening is usually implemented as data filters, routines or algorithms applied when entering data (included as default in pc-tablet applications or when new data is uploaded to the central database) or manually when new data is added to an existing claw database.

Check for data screening include:

a. valid animal-ID

b. valid claw disorder code

c. valid date

d. valid herd – ID (animal assigned at date of claw disorder to farm)

e. additional criteria for more optional recorded information (e.g. severity grades within range)

1.6.2 Data Verification

Data verification consists of checking the correctness of data. Completeness of data recording on farm should be considered as well. The exhaustiveness and the completeness of the process depends on the purpose of use and on the data sources:

1.6.2.1 Purpose of use

Depending upon the intended use, the quantity and quality of data is important, in relation to the purpose. At the farm level the farmer, or the trimmer/vet, will use the recorded data to manage cow-level decisions and to evaluate current claw health and to get an insight into causes of possible claw-health and lameness problems. Moreover, it is used to assess the effect of previous management measures, to take decisions on herd management and to understand the reasons of fluctuations of claw health status when they occur. Another use is for benchmarking analysis in order to define benchmarks and standards that serve as references for evaluating claw health status. Claw data are also used in genetic analyses, to estimate breeding values and genetic trends.

Herd management analysis requires as much complete data as possible, and should include as much information as possible about the risk factors. Therefore, this type of validation is usually less restrictive since it mainly checks the completeness of the data. If the data are used by the farmer, a basic data check is done on farm.

When it comes to data for research and routine genetic evaluation, data validation needs to be more exhaustive in order to use only information from farms that can be considered as reliable. The data editing process is usually more exhaustive in order to ensure data correctness.

For benchmarks, calculation and monitoring, data must be checked for representativeness. Information on herd size, housing system, and geographic location should be taken into account to ensure the data are representative. Herds with outlier parameters should be eliminated. The percentage of trimmed cows within herds must be as high as possible. Benchmarks are often calculated without considering environmental effects in the model. For interpretation and comparability of benchmarks environmental information included as well as information on calculation and data validation have to be considered as these might have a big impact on the results.

1.6.2.2 Source of data

The origin of data has an impact on the reference levels used to check data quality. Depending on the recording system, claw health data are recorded by trimmers, veterinarians and/or farmers. A large proportion of data is usually provided by trained trimmers who register claw health data during preventative trimming or treatments, while veterinarians generally register only the most severe cases. Thus, the majority of claw health data are recorded either by claw trimmers or herd staff and not by veterinarians. Therefore, the data provided by trimmers, or collected by farmers usually show a higher incidence rate than the data supplied by veterinarian. The diagnoses of veterinarians and claw trimmers, however, may be more accurate than those of farmers. The routine collection of information via claw trimmers may provide a much more reliable picture on the prevalence of claw disorders in dairy cattle. In most cases, we have to deal with a combination of data from different sources.

1.6.2.3 Editing criteria

In order to ensure the correctness and the accuracy of the data, several editing criteria have been reported within each level of data.

1.6.2.3.1 Trimmer/Vet data verification

In general, data on claw disorders are collected by hoof trimmers during scheduled (mainly), or emergency visits. A minimum number of records should be required per trimmer to ensure continuity and representativeness of the collected data (Perez-Cabal & Charfeddine, 2015). Data recorded in training periods should be removed. Besides, incidence rate for each disorder could be calculated and compared with the overall incidence rate of other trimmers (in the same area/country and time period) and checked whether it is within the range of e.g. two standard deviations (to ensure uniformity in recording and to detect under- or over-reporting).

Recommendation

a. minimum number of records per trimmer
b. check for continuity of data provision from trimmer
c. calculate incidence rates and variation per trimmer – see also 1.6.3 Monitoring and training for data recording.

d. check plausibility if data are generated by different persons

1.6.2.3.2 Herd level verification

Routines for claw trimming may vary, but trimming is often done once or twice a year for each cow. Typically, the farmer selects the cows to be trimmed, that is why a minimum number of records per herd and per year and **a minimum percentage of present cows trimmed per herd and year are required in order to avoid selection bias** (e.g. Van der Spek *et al.*, 2013). **For herd management, the percentage of cows trimmed should be used to establish the reference group for comparisons within herd**. Depending on the use of data, a minimum frequency could be required to avoid using data from herds that under-report (mainly used for genetic analysis and benchmarking calculation). Additional checks on herd-trimming days are used to ensure that a minimum percentage of present cows are trimmed and there is a minimum number of animals without disorder per visit (e.g. van der Waaij *et al.*, 2005). Because herd sizes, data structure and management practices vary among countries, the level of minimum incidence rate or the number/percentage of trimmed cows that are required needs to be defined accordingly to avoid a massive elimination of useful data.

Recommendation

a. check whether only trimmed cows are recorded
b. minimum incidence rate for a specific disorder or for overall disorders
c. minimum percentage of trimmed cows in herd in observation period
d. continuity of data provision from herd
e. note the strategy of trimming

1.6.2.3.3 Animal data verification

Checks at animal level are focused on verifying unique identification, herd location at trimming, age at calving, sire of the cow, days in milk and parity status. Claw disorders may be recorded for each claw. Moreover, in some recording protocols they differentiate between inner and outer claw. In some countries, claw disorder trait is defined at claw level, while in others the trait is defined at animal level and the score assigned to each animal is the highest value in case that the cow shows the same disorder on different claws.

Recommendation

a. correct animal-ID (see screening)
b. check for correct additional information (see chapter recording and trait definition)

1.6.2.3.4 Record verification

A claw disorder record describes the status of the claw at any given day. To validate a new record, we need to answer to the question whether this record defines a new episode with the same diagnosis or is a just a control of the same case. The time intervals used **to define the following diagnosis as a new event** for each disorder in the same claw is **4 months**.

Recommendation

a. check for new lesion or new case (see chapter 0)

1.6.2.4 Summary

Minimum criteria for validation for use in herd management:

a. screening requirements

Additional recommended criteria for use for genetic evaluation:

a. only valid herds (e.g. minimum % of trimmed cows)
b. valid observation period (e.g. with continuous data recording; minimum % of cows with disorders)
c. valid trimmers (e.g. continuous data provision; minimum amount of data within period; optional additional criteria)

Additional recommended criteria for benchmarking: define criteria depending on the reference level (e.g. herd size, breed, management system, etc.).

a. Herds included should have a high percentage of cows presented at trimming.

1.6.3 Monitoring and training for data recording

Data collectors, which can be trimmers, veterinarian or farmers, should be reliable and accurate in order to reflect a stable and consistent collection process across persons and over time. Data collector should apply the same disorder, the same definition and scoring scale. Therefore, having a good documentation process, training course and statistical monitoring are useful to ensure a good harmonization between data collectors.

The ICAR claw health atlas should be made available to all collectors, or at least a local guideline, which should contain pictures and definitions of the disorders based on ICAR claw health atlas definitions. Also, the used scale to score the disorders of different severity degrees should be made clear in this documentation.

Regular training sessions should be made to train data collectors and to discuss different recording interpretations. A comparison between experienced persons and new ones during practical sessions could be a good way to unify criteria. Moreover, ensuring consistency between data collectors should be done by checking data collectors criteria using pictures for different disorders with varying degrees of severity and are also considered very useful to reduce variability.

Statistical analysis of data collected by each data collector, such as a calculation of the frequency of each disorder and its deviations with the rest of group, could be useful to detect under-reporting or misunderstanding of the scoring scale. In case a disorder has more than two classes, the frequency of the scores can be compared between one person and the rest of a group. More detailed monitoring per person could be done by analysing the scores per lactation number of the cow. In case a large number of scores per data collector is available, is to compute the correlation between the scores of one data collector and the scores of rest of the group by using bivariate genetic analysis. This shows the quality of harmonisation of trait definition between data collectors (Veerkamp *et al.* 2002).

For this analysis, two data sets are created, one with scores of one data collector and the other with scores of all other data collectors from a certain period, for example 12 months. Both data sets can be analysed in a bivariate analysis, estimating different (genetic) parameters. The analysis can be carried out for each trait and for each data collector. Incidence rates per trimmer as well as from the bivariate analyses the heritability and genetic correlation can be used as indicators for data quality.

Recommendation

a. Frequencies/ incidence rates per trimmer.

b. Heritability: the heritability estimated within each data collector can be used as criteria for the repeatability of scores within data collectors, albeit the optimum value is not unity but depends on the true heritability of each disorder.

c. Genetic correlation: the genetic correlation between two data sets can be used as a measure of the repeatability between data collectors, where a genetic correlation of one between data collectors is expected.

1.6.4 Use of Claw Health Data – general

Data on the claw health status of each cow provides an important insight into the health status of the entire herd and population. Benchmark parameters like incidence and prevalence rates are used to monitor the degree of claw lesions within dairy herds and to highlight the full scale of claw health problems in the whole population. The values of such parameters depend on the frequency and the recovery period of each claw disorder, which are affected by cow and herd-related risk factors. The assessment of these risk factors helps to address why rates fluctuate within herds and how to fix them.

1.6.4.1 Risk factors

Many risk factors predisposing the occurrence of claw disorders have been reported in the literature. These risk factors can be related to herd management conditions or to the individual cow status (see

Annex 1: Risk factors for claw disorders).

For optimization of herd management as well as interpretation of benchmarks information related to risk factors is valuable. Targeted strategies to reduce the incidence of feet and legs disorders can be elaborated if this information is available.

1.6.4.2 Indicators/parameters for claw health

1.6.4.2.1 Incidence rate (IR)

Incidence rate describes the development of new cases of claw disorder. It is defined as the number of new cases of a specific claw disorder per unit of animal-time during a given time period. Incidence rate highlights the speed at which new cases of a disorder occur in the herd and therefore is more suited to assess claw health management policy.

Equation 1. Computation of incidence rate for claw health disorders.

$$IR = \frac{Number\ of\ \boldsymbol{new}\ cases\ in\ a\ defined\ time\ period}{Number\ of\ animal - time\ units\ at\ risk\ during\ the\ time\ period}$$

1.6.4.2.2 Prevalence rate (PR)

Prevalence rate describes the percentage of cows having a claw disorder. It is defined as a proportion of cows affected by a disorder at a particular time point or during a specified time period. Prevalence takes into account the new and the pre-existing cases whereas incidence includes only the new cases. It provides an appropriate snapshot to show the magnitude of the spread of a disorder within a given population at a certain point of time (point prevalence) or during a period of time (period prevalence). Prevalence rates calculated in different countries or studies to be comparable should be calculated in the same way and for the same production system (see Annex 2: Prevalence rates for claw disorders for different breeds in several countries)

Equation 2. Computation of prevalence rate for claw health disorders.

$$PR = \frac{Number\ of\ \boldsymbol{all}\ cases\ in\ a\ defined\ point\ or\ period\ of\ time}{Number\ of\ animal - time\ units\ at\ risk\ at\ the\ point\ or\ period\ of\ time}$$

1.6.4.2.3 Definitions for parameters calculation:

For the calculation of incidence and prevalence rates three important concepts should be defined:

a. Reference levels

   A key point for between the herds benchmarking process is how to compare with the appropriate benchmarking group and how to establish a target related to this group. For that reason, it is important to define a comparable reference level. Reference level could be defined by herd size, production level, geographic location, flooring and housing systems, season, parity, age and stage of lactation.

b. Cows at risk

   One of the challenges of a benchmark calculation is the definition of the denominator. By definition it should be equal to the number of cows at risk in the time period. However, the concept of "cows at risk during the time period" may be inaccurate if not all cows are trimmed or checked. So, if we consider cows at risk as cows present in the herd at any moment of the time period that means that non-

trimmed cows are assumed to be "healthy cows". While if we consider cows at risk as trimmed cows during the time period, then the calculated rates depend on the percentage of trimmed cows. In situations of regular lameness screening (every 1-4 weeks) then this assumption may be valid. Detection may also be influenced by the timing of the foot inspection, with lesion detection rates higher at 60-120 days into lactation in most herds. The other critical point is that we deal with open herds where animals are leaving and entering the herd throughout the time period. Dohoo et al. (2009) reported that animals for which there is a loss of follow-up during the time period are called withdrawals and the simplest way of dealing with them is to subtract half the number of withdrawals from the population at risk. However, calculating animal-days within the herd is perhaps the most precise way to account for withdrawals.

c. Time period at risk

Benchmark calculation should be performed on a reference period of time which allows a fair comparison within and across herds with different management systems and at different times of the year. The time period could be defined as a year, season or lactation period.

1.7 Use of claw trimming data for herd management

Herd management is a continuous process which involves decision making and supervision of claw health status. This process starts with recording all useful data that makes claw health monitoring feasible. Documentation on claw disorders allows farmers/hoof trimmers/ veterinarians to get an up-to-date report on claw health status at herd and animal levels. Trends of prevalence rate and incidence rate within the herd and comparison with reference levels should serve as a monitoring tool for claw health. If a value is determined to be out of the desired range, an assessment of the associated risk factors should be made to allow for the implementation of corrective actions. Claw health data for herd management has a use at two different levels.

At the cow level, documentation provides data about individual cow history and allows follow-up of the healing process and re-check requirements. At the herd level documentation provides data about timing during lactation/season of hoof trimming for maintenance and lesions.

Data from claw reports should answer the following questions:

a. Whether the claw health status has changed or not?

- The timing (lactation/season) of the change?
- Which cows are affected?

b. Whether the farms stated hoof trimming goals are being met?

- Is the claw health strategy/new treatment working?

Figure 4 and Figure 5 show examples of graphs which can help to answer those questions at herd level.

Claw disorders are often recurrent, and there are frequently several registers for the same disorder recorded on the same claw on different dates. When using claw health data for herd management, it is important to know whether the new register defines a new disease process for the same kind of lesion or is just a control for the same episode. Moreover, it is useful to define the concept of chronic cow or chronic lesion in order to take the optimum disposal decision. Cramer and Guard (2011) recommend the definition of both concepts at the level of cow's lactation instead of at the claw's lesion level because claw disorders on different limbs are not really independent and unless we follow very closely we cannot be sure that different records at different moments of lactation are due to different disease processes.

Figure 2. Example of herd management report which describes the occurrence of claw disorders at different dates (Cramer, 2018).

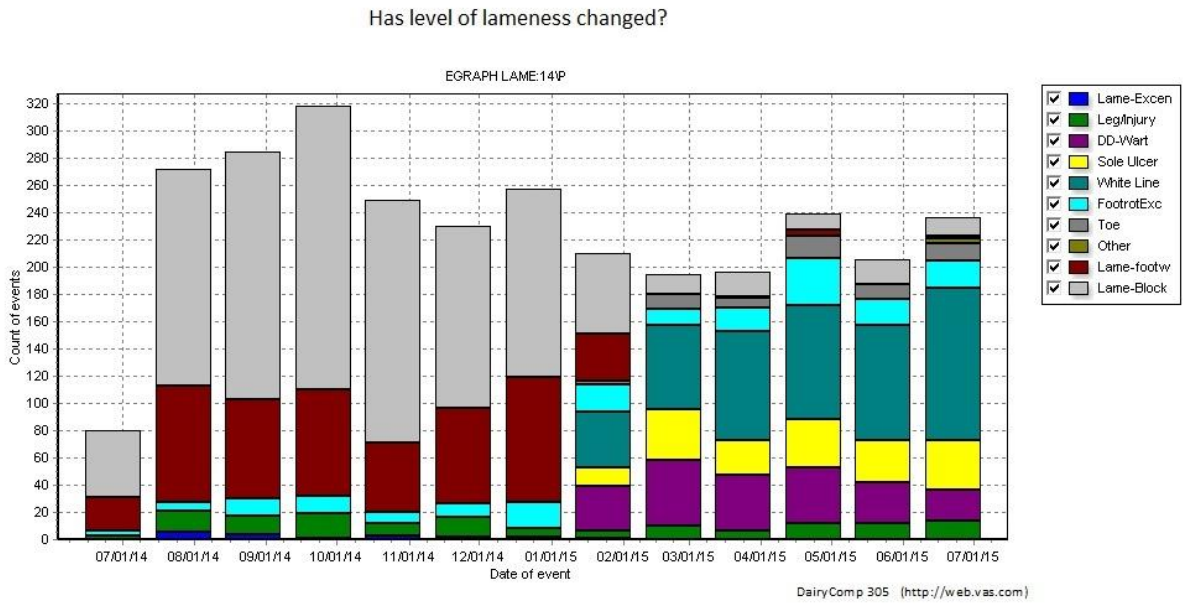

Figure 3. Example of herd management report which describes the occurrence of first lesions over the course of the lactation.

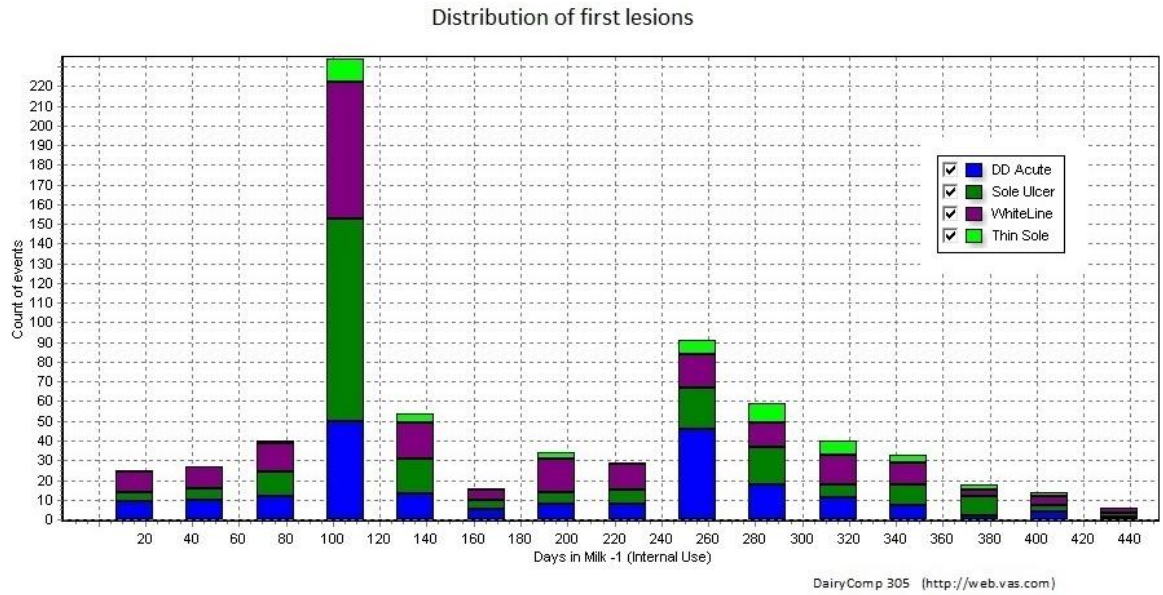

Figure 4. Example of herd management report which describes the occurrence of first lesions over the course of the lactation within each lactation group.

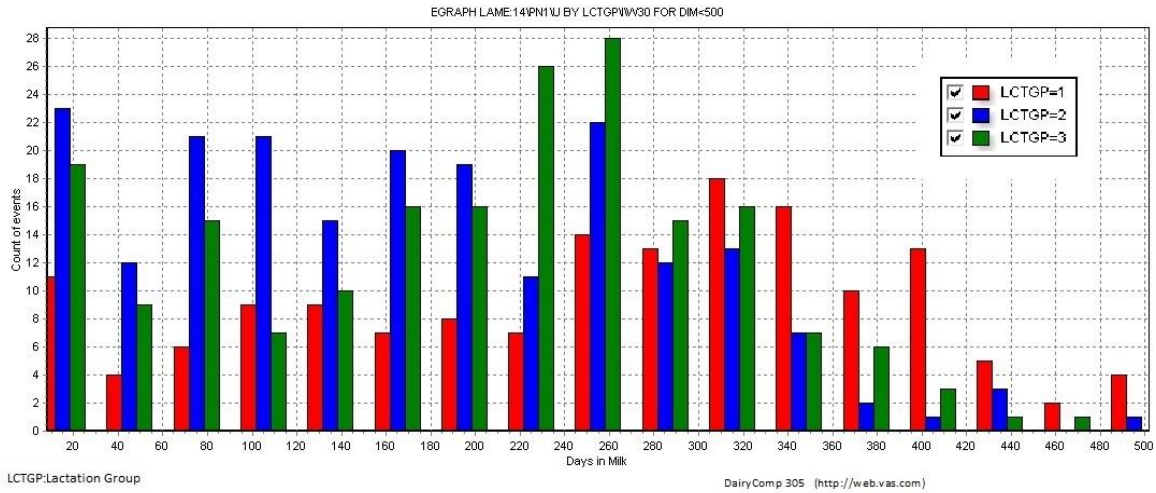

Figure 5. An example of a herd management report which displays a list of not trimmed cows.

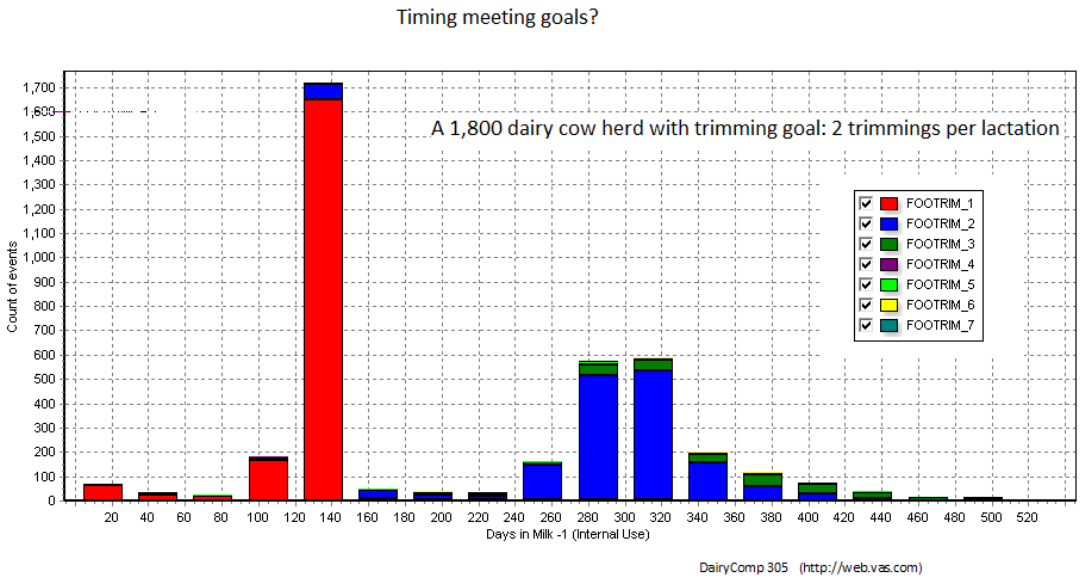

Figure 6 and Figure 7 show the list of not trimmed cows and cows showing lesions in the last three trimmings, respectively.

Figure 6. An example of herd management report which displays a list of cows with lesions in the last trimming sessions.

Foot Health As of **Apr 25, 2018**

Farm Name	Herd Number	Current Herd Count	Housing / Milking System	Last Trim Date
Farm Name	**99999**	**331**	**Free Stall / Milking Parlour**	**Feb 7, 2018**

Animals Not Trimmed

Summary Animals Not Trimmed Lesions
Include: Cows Heifers Both

Months without Trimming 1 5 9 13 17 21

Name of cow	Visible ID No	Age	Breed	Entered Herd Date	Last Trim Date	Number of Lesions
PARSLEY	001405	2y 3m	JE	Jan 11, 2016		
PITA	001410	2y 2m	JE	Feb 9, 2016		
DONUT	001415	2y 1m	HO	Mar 1, 2016		
MILKSHA	001417	2y 1m	HO	Mar 8, 2016		
HUMMUS	001420	2y 1m	HO	Mar 16, 2016		
SALAD	001422	2y 1m	HO	Mar 24, 2016		
DELICIO	001431	1y11m	HO	May 1, 2016		
NOEL	001232	4y 5m	HO	Nov 18, 2013	Jul 27, 2016	0
SOCHI	001253	4y 2m	HO	Feb 17, 2014	Oct 26, 2016	2
POINSET	001079	6y 4m	JE	Dec 24, 2011	Nov 23, 2016	0
DIDIT	001141	5y 7m	HO	Sep 7, 2012	Nov 23, 2016	0
PINK	001255	4y 1m	JE	Mar 4, 2014	Nov 23, 2016	0
JUMBALY	001113	5y11m	XX	May 9, 2012	Dec 21, 2016	0
PURPLE	001257	4y 1m	JE	Mar 7, 2014	Dec 21, 2016	0
DIANA	000696	10y 8m	HO	Aug 24, 2007	Jan 25, 2017	5

Figure 7. An example of herd management report which displays a list of cows with lesions in the last trimming sessions.

Foot Health As of **Apr 25, 2018**

Farm Name	Herd Number	Current Herd Count	Housing / Milking System	Last Trim Date
Farm Name	**99999**	**331**	**Free Stall / Milking Parlour**	**Feb 7, 2018**

Animals with Lesions in the Last 3 Trim Sessions

Summary Animals Not Trimmed Lesions
Include: Cows Heifers Both

Name of cow	Visible ID No	Age	Total Lesions	Housing	Trim Date	Lesion	Severity	Foot Claw
CHILLI	001197	4y 9m	6	Free	Feb 7, 2018	DD	M4.1	RLI
						DD	M4.1	RRI
					Jan 10, 2018	DD	M4.1	RLI
						DD	M4.1	RRI
					Nov 2, 2017	DD	M2	RRI
						DD	M2	RLI

1.8 Use of claw trimming data for benchmarking and monitoring

Benchmarking is a useful tool to compare performance and the need for improvement (Von Keyserlingk *et al.*, 2012; Bradley *et al.*, 2013). Besides, it also helps to illustrate the potential benefits that improvements might offer; it can also motivate producers to adopt preventive practices and to foster the documentation of claw data. The success of any benchmarking process depends on the use of appropriate benchmarks. Incidence and prevalence rates are key parameters that can be used to make comparisons among and within herds over time (Dohoo *et al.*, 2009).

Claw health data should be able to answer the following questions:

a. What is the current status?

b. Does the situation change and do I need to investigate further?

c. Which age group and which lactation stage are affected?

d. What is the gap between the current situation and the reference level?

A useful benchmarking report should be straightforward and concise, supported by clear and informative tables and charts showing a snapshot or a trend of incidence or prevalence rate. Figures as pie chart, bar chart and/or radial chart provide a graphical assessment of claw health status. Figure 8 and Figure 9 show examples of the Canadian DHI foot health benchmark report. Figure 8 displays the frequency of claw disorders within 12-month period and compare it with different benchmarks calculated for different group of animals (heifers, cows) and three different combinations of production systems (Free-stalls with robot, Freestalls with milking parlour, and Tie-stalls). Figure 9 displays a table with healthy/lesion count for each month and throughout the year at the herd, provincial, and national levels. The colored block indicates the range of the herd's percentile rank.

Figure 8. An example of a report which displays a healthy/lesion count for each month and throughout the year.

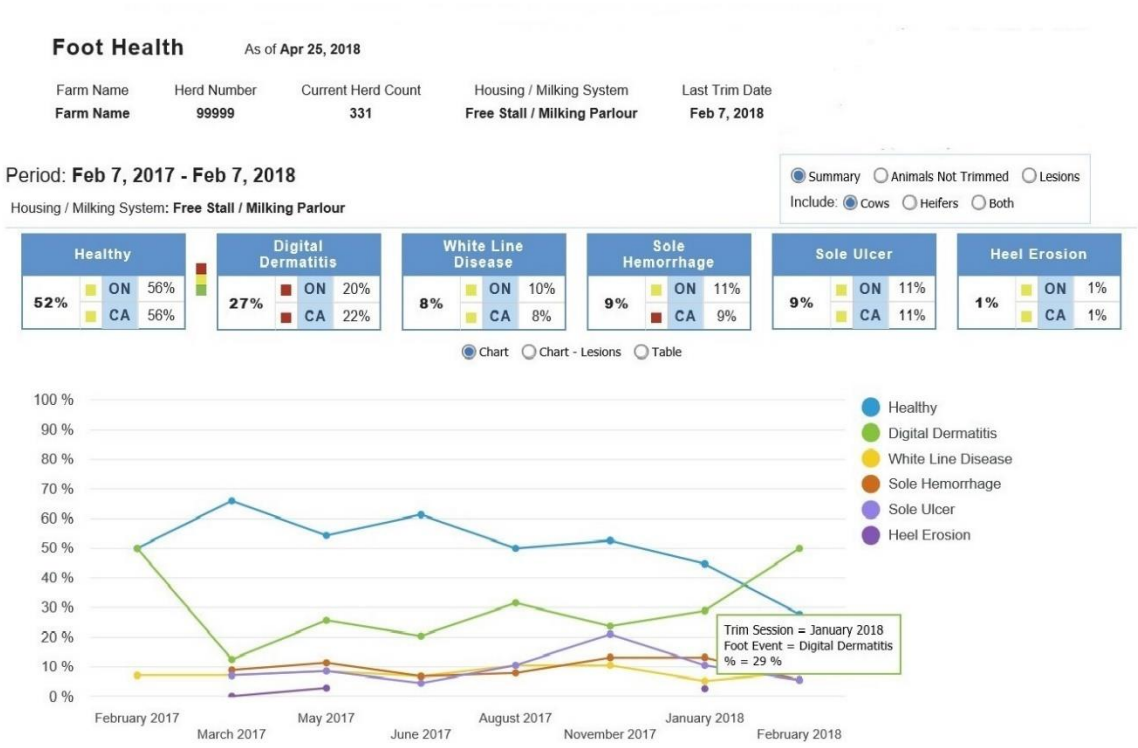

Figure 9. An example of a report which displays a healthy/lesion count for each month and throughout the year.

Cows															
Trim Session	Count	Presented for Trimming		Healthy		Digital Dermatitis		White Line Disease		Sole Hemorrhage		Sole Ulcer		Heel Erosion	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
February 2017	161	14	9	7	50	7	50	1	7	0	0	0	0	0	0
March 2017	160	56	35	37	66	7	12	4	7	5	9	4	7	0	0
May 2017	157	35	22	19	54	9	26	3	9	4	11	3	9	1	3
June 2017	156	44	28	27	61	9	20	3	7	3	7	2	5	0	0
August 2017	159	38	24	19	50	12	32	4	11	3	8	4	11	0	0
November 2017	162	38	23	20	53	9	24	4	11	5	13	8	21	0	0
January 2018	168	38	23	17	45	11	29	2	5	5	13	4	11	1	3
February 2018	163	36	22	10	28	18	50	3	8	2	6	2	6	0	0
Herd		**299**	**22**	**156**	**52**	**82**	**27**	**24**	**8**	**27**	**9**	**27**	**9**	**2**	**1**
Province					56		20		10		11		11		1
Canada					56		22		8		9		11		1

1.9 Use of claw trimming data for genetic evaluation

Routine recording of claw health status at claw trimming provide valuable data for genetic evaluations. This section covers issues related to genetic evaluation of claw health, such as data sources, trait definitions, models and genetic parameters. For more detailed information we refer to the review paper by Heringstad and Egger-Danner *et al.* (2018).

1.9.1 Data sources

Different sources of data and traits can be used to describe and evaluate claw health. The most reliable and comprehensive information is data from claw trimming, and use of these data is the scope of the guidelines. Possible indicator traits include veterinary diagnoses, data from lameness and locomotion scoring, activity-related information from sensors, and feet and legs conformation traits. Indicators may be useful in genetic evaluations, but this is not discussed here.

1.9.2 Trait definition

Claw disorders are usually defined as binary traits, based on whether or not the claw disorder was present (recorded) at least once during a defined time period (opportunity period), usually from calving to day 305 or end of lactation.

Binary coding can be based on single specific disorders (i.e. each diagnosis is one trait) or groups or composite traits. Traits can be grouped according to aetiology and pathogenesis, e.g. infectious and non-infectious disorders, or grouping of all diagnoses as any (all) disorder. Grouping is often chosen in situations with limited data and/or low frequency of single disorders. If linear models are used the heritability will be higher for group traits than for the specific disorders as a result of higher frequency. Grouping might make comparisons for use in international evaluations difficult. Harmonized descriptions of individual disorders are important.

Alternatively, to take multiple occurrences into account can claw disorders be defined as the number of cases during a defined period time. This requires a clear definition of new cases. Also recording at the level of individual legs may be needed to accurately define new cases.

Claw health records from different parities can be treated as repeated measures of the same trait or as multiple traits. High genetic correlations justify treating claw disorders as the same trait across parities. There is a wide range of estimated correlation in the literature (e.g. van der Linde *et al.* 2010; van der Spek *et al* 2015) so this should be checked in each case. Similarly, there is a question on whether the same disease occurring at different stages at lactation (e.g. early-, mid- and late lactation) should be assumed to be the same trait.

Which animals to define as cows with no claw disorders present (i.e. healthy herd mates) may be challenging as herd trimming strategies and recording practices vary. Ideally should all cows in a herd be trimmed and status of all cows, including those with normal/healthy claws, should be recorded at trimming. In most cases not all the cows be trimmed and there is a question whether non-trimmed cows should be included as healthy herd mates or excluded from the genetic analyses. Assuming that all non-trimmed cows are healthy underestimates the incidence of claw disorders (mild cases could be present, but not detected), while including only trimmed cows may overestimate the incidence (non-trimmed cows are more likely to be unaffected).

Key issues related to trait definition:

a. Binary trait or number of cases?

b. Single specific disorders or groups/composite traits?

c. Length of opportunity period?

d. Same trait across parities?

e. Same trait across stage of lactation?

f. Include or exclude non-trimmed cows?

1.9.3 Models

Effects to consider in models for genetic evaluations of claw heath, in addition to standard effects such as age, contemporary group, and lactation number, include effects of time (lactation stage) at trimming and trimmer. The latter requires that a unique ID is recorded for each trimmer. Lactation stage at trimming can be the number of days or weeks between calving and trimming. The timing of the occurrence of disease probably is less accurate when based on claw trimming rather than veterinary treatment data. Depending on the herd's claw-trimming routine there may be some time between the occurrence of a problem and the trimming day, and milder cases may go unnoticed until trimming.

The considerations regarding choice of model for genetic evaluation for claw health will be the same as for other categorical traits. Although more advanced models may be advantageous as they utilize more of the available information, linear models may often be the model of choice for routine genetic evaluation as they are fast, easy to implement, and gives in most cases very similar ranking of animals as more advanced models.

1.9.3.1 Genetic parameters

Heritability of the most commonly analysed claw disorders based on data from routine claw trimming were in general low (Table 4[1]), with linear model estimates ranging from 0.01 to 0.14 and threshold model estimates ranging from 0.06 to 0.39. For the composite trait overall claw health (any lesion) estimated heritability varied from 0.05 to 0.07 from linear model, and from 0.07 to 0.13 from threshold model.

Table 4. Range of heritability estimates for the most common claw disorders

Trait	Threshold model	Linear model
Digital / interdigital dermatitis	0.09 - 0.20	0.01 - 0.11
Heel horn erosion	0.09	0.03 - 0.07
Interdigital hyperplasia	0.19 - 0.39	0.01 - 0.14
Sole hemorrage	0.07 - 0.09	0.02 - 0.08
Sole ulcer	0.07 - 0.18	0.01 - 0.12
White line disease	0.06 - 0.10	0.01 - 0.09

[1] From Heringstad and Egger-Danner *et al*, 2018.

Estimated genetic correlations among claw disorders varied from -0.40 to 0.98 (Table 5[2]). The strongest genetic correlations were found among sole hemorrhage (SH), sole ulcer (SU), and white line disease (WL), and between digital/interdigital dermatitis (DD/ID) and heel horn erosion (HHE). Genetic correlations between DD/ID and HHE on the one hand and SH, SU, or WL on the other hand were low in most cases.

Table 5. Range of genetic correlation estimates among digital and/or interdigital dermatitis (DD/ID), heel horn erosion (HHE), interdigital hyperplasia (IH), sole hemorrhage (SH), sole ulcer (SU), and white line disease (WL) (from Heringstad et al, 2018)

	HHE	IH	SH	SU	WL
DD/ID	0.58 - 0.87	0.10 - 0.66	-0.15 - 0.12	-0.19 - 0.56	-0.33 - 0.08
HHE			-0.07 - 0.23	-0.05 - 0.50	0.22 - 0.36
IH			-0.40 - 0.13	-0.08 - 0.50	-0.35 - 0.34
SH				0.38 - 0.90	0.10 - 0.62
SU					0.01 - 0.98

1.9.3.2 Implications

Genetic improvement of claw health is possible. However, the traits show low heritability and large scale routine recording is needed for reliable genetic evaluations. The genetic correlations to indicator traits like feet and leg conformation is low so direct selection based on genetic evaluation based on trimming data will be most efficient. As comprehensive recording of hoof trimming data is challenging it is recommended to use other direct or indirect information for genetic evaluation as well as for herd management.

1.10 Summary Check List

These guidelines provide recommendations on recording, validation, monitoring and use of claw health data.

1.10.1 Data Recording

For data recording the minimum requirements should be:

- Animal-ID
- Herd-ID
- Records on animal level
- Date of trimming

[2] From Heringstad and Egger-Danner *et al*, 2018.

Trimmer-ID is highly recommended but not compulsory (it is essential for data validation but also very valuable for the use of the data). Other additional information could be useful as:

- Recording the location of the disorder/lesion: leg (e.g. left front leg), claw (inner or outer claw), positions (claw zones)
- Recording of severity degree: e.g. mild, severe, M-stages for DD

1.10.2 Data Validation

For data validation two steps have been defined: data screening and data verification.

Before data entry in the database, the information should be screened in order to ensure completeness and correctness of the data. The check should include:

- Valid animal-ID
- Valid claw disorder code
- Valid date
- Valid herd – ID (animal assigned at date of claw disorder to farm)
- Additional criteria for more optional recorded information (e.g. severity grades within range)

Before conducting further analyses, data must be verified in order to ensure that the data is fitted for the intended use. That is why the check depends on the purpose of use and on the data sources.

1.10.3 Genetic Analysis

For genetic analyses several editing criteria have been reported within each level of data.

At trimmer level:

- Minimum no of records per trimmer
- Check for continuity of data provision from trimmer
- Calculate incidence rates and variation per trimmer – see also training of hoof trimmers
- Check plausibility if data are generated by different persons

At herd level:

- Check for valid herds (e.g. minimum % of trimmed cows)

At animal level:

- Correct animal-ID (see screening)
- Check for correct additional information

At record level:

- Check for new lesion or new case

1.10.4 Benchmark

For benchmarks calculation editing criteria depending on the reference level (e.g. herd size, breed, management system, etc.) should be defined.

- Herds included should have a high percentage of cows presented at trimming.

- Valid observation period (e.g. with continuous data recording; minimum % of cows with disorders)
- Valid trimmers (e.g. continuous data provision; minimum amount of data within period; optional additional criteria)

1.10.5 Monitoring and Training

Monitoring and training process for data collectors is highly recommended in order to achieve a consistent collection process across persons and over time. Statistical analysis should include the calculation of:

- Frequencies/ incidence rates per trimmer.
- Heritability: the heritability estimated within each data collector can be used as criteria for the repeatability of scores within data collectors, albeit the optimum value is not unity but depends on the true heritability of each disorder.
- Genetic correlation: the genetic correlation between two data sets can be used as a measure of the repeatability between data collectors, where a genetic correlation of one between data collectors is expected.

1.10.6 Use of claw health data

Data on the claw health status at cow or claw level are used for herd management, benchmarking and genetic analyses.

For herd management data from claw reports should answer the following questions:

- Whether the claw health status has changed or not?
- The timing (lactation/season) of the change?
- Which cows are affected?
- Whether the farms stated hoof trimming goals are being met?

Benchmarking is a useful tool which success depends on the use of appropriate key parameters and reference levels. Benchmarking reports should be able to answer the following questions:

- What is the current performance?
- What is the position within the reference group?

Genetic improvement of claw health is possible even though claw disorder traits show low heritability. A large scale routine recording system for claw trimming data is highly needed for reliable genetic evaluations.

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1.13 Annex 1: Risk factors for claw disorders

Claw disorders have a multifactor aetiology where risk factors for their occurrence could be deficiencies in housing systems and husbandry conditions, diet, hygiene, hoof trimming management, insufficient horn quality (for any reasons) as well as exposure to contagious agents and intoxications of certain minerals (Clarkson *et al.*, 1996; Bergsten, 2001; van der Linde *et al.*, 2010; Zinpro Corporation, 2014). A summary of the main risk factors related to the cow and related to the farm for infectious and non-infectious claw disorders are compiled in Table 6[3].

As for other health conditions, the most critical period regarding occurrence of claw disorders is the time around calving; therefore, besides general improvement of the cow's environment, optimization of the transition period can be seen as an important factor for prevention.

A main farm risk factor for feet and legs problems is the type of surface the cows lay or walk on (Somers *et al.*, 2003). Most systems in Europe and North America have prolonged periods of time throughout the year where cattle are confined indoors, often on solid concrete or slats and fed conserved diets. If cattle do not have enough space for sleeping, walking and moving freely, longer periods of standing negatively impact claw health. Housing systems that do not allow appropriate consideration of the social status due to overstocking or too narrow walking paths or too few or uncomfortable cubicles increase the risk for claw disorders (Holzhauer *et al.*, 2006; Fiedler, 2015). Different roles of risk factors in pathways which lead to specific claw pathology may explain, why lower prevalence's of foot lesions were reported for cows housed in tie stalls than for those housed in free stalls (Cramer *et al.*, 2008). Hygiene deficiencies on farm as well as contact between cows from different herds increase the risk for claw disorders related to infections like DD. Repeated contact to infectious agents may also contribute to the not consistently lower prevalence of claw disorders in cows with than without access to pasture: Regularly passed alleyways and too small pasture size bear the risk of cross-contamination, whereas claw health should generally benefit from opportunities of free movement on natural ground.

Some types of claw disorders are associated with diet composition. Rations with a high level of easily digestible carbohydrates and a high percentage of protein together with a low level of fibre may result in a disturbance of the digestion and increased risk of claw disorders.

The occurrence of claw disorders is also influenced by genetics, with some variation between the specific disorders. Therefore, in addition to improving management and nutrition, breeding for improved claw health is an important way of stabilizing and improving claw health. Breeding measures have the potential to achieve sustainable progress if enough emphasis is put on these traits in the breeding goal and the breeding program.

[3] Mülling *et al.* 2006; Palmer *et al.* 2015; Barker *et al.* 2009.

Table 6. Risk factors and their associated claw disorders.

Type of disorders	Risk factors		Preventive and risk effects	Associated disorders
Infectious disorders	Cow-related factors	Calving Age Breed Immunity system	Around calving cows suffer stress and a depression of immunity system which favour the spread of infectious disorders. Young animals are most at risk as they have less developed immunity system. Holstein-Friesian cows are more susceptible than other breed. The individual immunity response has been reported as a preventive factor against infectious disorders	Digital dermatitis Interdigital phlegmon Heel erosion Interdigital dermatitis
	Farm-related factors	Cow comfort Stall design Pen size Parlour capacity	Cow comfort maximizes lying times and reduces stress. Reduces also contact with manure. Good stall design facilitates the cleaning process.	Digital dermatitis Interdigital phlegmon Heel erosion Interdigital dermatitis
		Cow hygiene Dry environment Slurry free environment	Cleanliness reduces contact between pathogen and host. Prevents introduction of infectious pathogens	Digital dermatitis, Heel erosion Interdigital dermatitis
		Housing system Access to pasture Straw yard	Access to pasture or straw yard reduces infectious disorders and accelerate healing process	Digital dermatitis Heel erosion Interdigital dermatitis

Type of disorders	Risk factors		Preventive and risk effects	Associated disorders
		Diet	Diet affect immunity system mainly at early calving	Digital dermatitis Interdigital phlegmon Heel erosion Interdigital dermatitis
		Correct foot bath routine	foot bathing aid in prevention of the initial infection and reduce the development of complicate infections	Digital dermatitis Heel erosion Interdigital dermatitis
Non-Infectious disorders	Cow-related factors	Calving Age Breed	Disruptions to the growth of horn around the time of calving, which can lead to poor-quality horn formation	Sole hemorrhage Concave dorsal wall Sole ulcer
	Farm related factors	Cow comfort Maximizing lying times Comfortable lying surface	Reduces wear on the sole Reduces pressure on the feet Reduces damage to the bony prominences	Sole ulcer Hock damage/swelling White line disease
		Housing system	Tied animals show less hoof lesions than those in loose housing. Free-stall barns mean long walking distances between the cubicles, feeding and drinking stations and the milking parlour. Good design and good walking surfaces might be the mitigate factors	White line disease

Type of disorders	Risk factors		Preventive and risk effects	Associated disorders
		Flooring system Walking and standing surfaces	Rough and abrasive walking and standing surfaces lead to excessive wear and too smooth surfaces lead to slipping. Concrete floor has been shown to increase claw horn disorders. Rubberized walking surfaces in the feed alleys have been proven as preventive measures.	Sole ulcer Heel ulcer Double sole Hock fissure White line disease
		Social and physical integration for heifers and dry cows	Reduces defensive movements Avoids cow to cow confrontation. Reduces standing times Improves eating and drinking behaviour	White line disease
		Cow flow on the farm Good routes around Buildings To pasture To feed	Allow a cow to express normal gait Reduces defensive movements from humans to avoid confrontation Reduces standing times Improves eating and drinking behaviour	White line disease Sole ulcer
		Diet Macronutrients Micronutrients	Not only the diet composition, but also the way it is prepared and fed. The reduction of ruminal acidosis and macro and micronutrient deficiencies or excesses improves hoof horn quality and integrity.	Sole haemorrhage Concave dorsal wall White line disease Sole ulcer

Type of disorders	Risk factors		Preventive and risk effects	Associated disorders
		Correct routine professional functional preventive hoof trimming	Corrects abnormal growth of the hoof horn Prevents excessive/abnormal wear Prevents areas of deep sole horn Interrupts vicious circle of increased horn production Balances the weight load on lateral & medial claw Avoids high loading of localized areas of the sole	Sole haemorrhage Concave dorsal wall Hock fissure White line disease Sole ulcer

1.14 Annex 2: Prevalence rates for claw disorders for different breeds in several countries

Table 7 shows prevalence rates for claw disorders calculated in different countries during 2015. In Finland, prevalence rates are calculated for Ayrshire and Holstein breed, while in The Netherlands parameters are calculated making distinction between first parity and multi-parity cows. Prevalence rates show a large variation between countries and illustrate some of the problems associated with between herd benchmarking. These differences could be explained by several reasons: Firstly, differences in the reporting level for some disorders, in fact within the same country the recording could be different across trimmers or practitioners. Secondly, the definition of claw disorders may not be completely the same. Thirdly, differences of the percentage of cows recruited for trimming. Finally, housing systems and weather conditions are different in these countries.

Table 7. Annual prevalence rates of claw disorders calculated in different countries and for different breeds and group of cows.

		Denmark	Finland	France	Netherlands	Spain	Sweden
1	Interdigital Hyperplasia (IH)	6.0	AY: 1.5. HOL: 2.4	11.7	COWS:6.0;HF:2.5	0.22	4.1
2	Asymmetric Claws (AC)	1.7	AY: 0.1. HOL: 0.0				3.9
3	Corkscrew Claws (CC)	0.8	AY: 8.6. HOL: 6.3	3			1.7
4	Concave Dorsal Wall (CD)	0,0		2.9		0.76	
5	Digital Dermatitis (DD)	20.1	AY: 0.8. HOL: 1.3	29.8	COWS:21.0;HF:23.5	9.42	4.1
6	Double Sole (DS)	4.3	AY: 1.4. HOL: 1.8	4.6			2.2
7	Horn Fissure (HF)			2.2			
8	Vertical Horn Fissure (HFV)						
9	Horizontal Horn Fissure (HFH)						
10	Axial Vertical Fissure (HFA)						
11	Heel Horn Erosion (HHE)	10.8	AY: 10.2. HOL: 11.4	54.5			17.2
12	Interdigital Dermatitis (ID)	2.3	AY: 1.5. HOL: 2.5	1.41	COWS:17.8;HF:10.6		6.9
13	Interdigital Phlegmon (IP)	0.2	AY: 0.4. HOL: 0.4	0.7		0.75	0.2
14	Scissors Claws (SC)	0.7	AY: 0.1. HOL 0.4				
15	Sole Hemorrhage (SH)	20.1	AY: 16.4. HOL: 19.8		COWS:24.2;HF:23.2		17.8

		Denmark	Finland	France	Netherlands	Spain	Sweden
16	Diffused Form (SHD)			43.5			
17	Circumscribed Form (SHC)			16.2			
18	Sole Ulcer (SU)	6.1	AY: 3.0. HOL: 5.7	5.8	COWS:10.7;HF:4.0	12.87	4.8
19	Typical Sole Ulcer (SUTY)						
20	Bulb Ulcer (SUB)						
21	Toe Ulcer (SUTO)		AY: 0.1. HOL: 0.2				0.1
22	Toe Necrosis (TN)	0.7		1.8			
23	Swelling of the Coronet and/or the Bulb (SW)						
24	Thin Sole (TS)						
25	White Line Disease (WLD)			15.1	COWS:21.0;HF:12.9	8.85	
26	WL Fissure (WLF)	8.2	AY: 10.1. HOL: 13.1				2.2
27	WL Abscess/Ulcer (WLA)	2.5	AY: 1.0. HOL: 1.5				0.4
	All lesions				COWS:61.9; HF:43.4	30.51	