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Incidences of claw lesions in Austrian dairy herds in relation to lactation number, lactation month, housing system and breed

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Summary

Claw health of Austrian dairy herds was evaluated using data collected in the project 'Klauen-Q-Wohl' from 28,638 cattle in 526 dairy farms. We calculated the incidence of claw lesions and examined the relationships between cumulative incidence of claw lesions and lactation number, lactation month, housing type and breed. Claw health data were electronically documented by hoof trimmers from 2010 to 2019. Data were subjected to validity checks and hoof trimmers underwent inter-observer reliability testing.

During the observation period of ten years, only 12.4 % of cows were hoof-trimmed at approximately and after 305 days, 28.3 % during their first 100 DIM and 59.3 % between their 101 and 305 DIM. The

Zusammenfassung

Inzidenzen von Klauenläsionen in österreichischen Milchkuhherden in Abhängigkeit von Laktationszahl, Laktationsmonat, Aufstallungsform und Rasse

Ziel dieser Studie war die Auswertung von Klauenläsionen österreichischer Milchviehherden aus dem Projekt 'Klauen-Q-Wohl' mit Berechnung der Inzidenzen von Klauenläsionen sowie die Überprüfung auf statistische Zusammenhänge zwischen den Inzidenzen der Klauenläsionen und Laktationszahl, Laktationsmonat, Haltungsform und Rasse.

Die Klauenbefunde waren in den Jahren 2010–2019 von Klauenpflegern elektronisch dokumentiert worden. Die Daten waren einer Validitätsprüfung und die Klauenpfleger einem Interobserver-Reliability-Test unterzogen worden. Für die statistischen Analysen wurden die Daten von 28.638 Rindern aus 526 Milchviehbetrieben ausgewertet.

Im Beobachtungszeitraum von zehn Jahren wurden um und nach den 305. Laktationstag nur 12,4 % der Kühe, in den ersten 100 Laktationstagen 28,3 % und zwischen dem 101. und 305. Laktationstag 59,3 % der Kühe klauengepflegt. Die mittleren Inzidenzen in diesem 10-Jahres-Zeitraum betrugen bei Ballenhornfäule 59,2 %, bei Weiße-Linie-Defekten 42,6 %, bei Dermatitis digitalis (DD) 29,5 %, bei Geschwüren an allen Klauenlokalisationen 14,2 % und bei Alarmerkrankungen insgesamt 29,5 %. Alarmerkrankungen sind Klauenläsionen, welche immer mit Schmerzen und daher mit Lahmheit einhergehen. Die DD-Herdenprävalenz lag im

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mean incidences during the ten-year-observation period were 59.2 % for heel horn erosion, 42.6 % for white-line-lesions, 29.6 % for digital dermatitis (DD), 14.2 % for ulcers at all claw locations and 29.5 % for claw lesions that are always associated with pain and lameness ('alarm' lesions). Herd prevalence of DD in 2019 was 48.9 %. Cows in higher lactations had significantly higher incidences of concave dorsal walls, sole haemorrhages, sole ulcers, white-line-lesions and heel horn erosion, while heifers, cows in their first two lactations and cows around parturition showed significantly higher incidences of DD and interdigital phlegmon (foot rot). The mean incidence of all claw lesions was significantly ($p<0.05$) higher in cows kept in loose housing systems (85.3 %) than in cows kept in tie stalls (79.6 %). Fleckvieh cows had the highest overall incidence of all claw lesions of 89.5 %, followed by Holstein Friesian cows with 87.4 % and Brown Swiss cows with 72.1 %. 'Alarm' lesions (44.3 %) and DD (42.1 %) were most frequent in Holstein Friesian cows. To reduce the incidence of claw lesions, hoof trimming at dry-off and again around 40–60 DIM could be implemented, with significant benefits to claw health.

Jahr 2019 bei 48,9 %. Kühe in höheren Laktationen wiesen signifikant höhere Inzidenzen an konkaven Vorderwänden, Sohlenblutungen, Sohlengeschwüren, Weiße-Linie-Erkrankungen und Ballenhornfäule auf. Kalbinnen (Färsen) und Kühe in den beiden ersten Laktationen sowie Kühe um die Geburt zeigten signifikant häufiger DD und Zwischenklauenphlegmone. Die mittlere Inzidenz aller Klauenläsionen war bei Kühen aus Laufställen mit 85,3 % signifikant ($p<0,05$) höher als bei Kühen in Anbindehaltung mit 79,6 %. Fleckvieh-Kühe hatten dabei mit 89,5 % die höchste Inzidenz, gefolgt von Holstein-Friesian-Kühen mit 87,4 % und Brown Swiss-Kühen mit 72,1 %. Im Vergleich zu den beiden anderen Rassen wurden bei Holstein-Friesian-Kühen am häufigsten Alarmerkrankungen (44,3 %) und DD (42,1 %) dokumentiert.

Die regelmäßige Klauenpflege der Kühe beim Trockenstellen und zwischen dem 40.–60. Laktationstag könnte kurzfristig umgesetzt werden, wodurch die Inzidenz von schmerzhaften Klauenerkrankungen reduziert und positive Auswirkungen auf die Klauengesundheit erzielt werden könnten.

Abbreviations: ALARM = 'Alarm' lesions; BU = Bulb ulcer; CD = Concave dorsal wall; CHDL = Claw horn disruption lesions; DD = Digital dermatitis; DIM = Days in milk; DS = Double sole; HF = Horn fissure; HFA = Axial horn fissure; HHE = Heel horn erosion; IH = Interdigital hyperplasia; IP = Interdigital phlegmon (foot rot); SH = Sole haemorrhage; SU = Sole ulcer; SW = Swelling of coronet and/or bulb; TU = Toe ulcer; TN = Toe necrosis; WLA = White-line-abscess; WLD = White-line-disease

Introduction

Claw disorders are the main cause of lameness in many Austrian dairy herds (Fuerst-Waltl et al. 2021; Kofler et al. 2022; Lemmens et al. 2023). About 85% of all lameness events are due to claw disorders (Murray et al. 1996), and those are responsible for 7.5% of annual culling in dairy cows in Austria and claw disorders (Rinderzucht AUSTRIA 2022). A distinction is made between non-infectious (pressure-related) and infectious claw disorders and genetically caused deformities, such as corkscrew, scissor and asymmetrical claws (Machado et al. 2010; Refaai et al. 2013; Cook et al. 2019). Non-infectious claw horn disruption lesions (CHDL) include concave dorsal wall (chronic laminitic claw; CD), sole haemorrhage (SH), double sole (DS), sole ulcer (SU), bulb ulcer (BU), toe ulcer (TU), toe necrosis (TN), white-line-disease (WLD), white-line-abscess (WLA), vertical and horizontal horn fissures (HF) and thin sole. All these CHDLs, as well as interdigital hyperplasia, have largely mechanical, traumatic, management or feeding-related causes (Machado et al. 2010; Foditsch et al. 2016; Garvey 2022; Kofler et al. 2023). Infectious claw diseases include digital dermatitis (DD), interdigital dermatitis and interdigital phlegmon (foot rot; IP). They are always caused by anaerobic bacterial infection coupled with predisposing factors (Refaai et al. 2013; Osová et al. 2017). Claw disorders are described in the ICAR Claw Health Atlas and its two appendices (Egger-Danner et al. 2015; Kofler et al. 2020a,b). Some claw lesions are often not associated with clinically apparent lameness (Tadich et al. 2010; Kofler et al. 2013) and in many cases they represent non-painful lesions on the claw horn or the skin around the claws. Claw disorders that are always associated with pain and lameness are referred to as 'alarm' lesions, which emphasizes their importance for animal welfare (Kofler et al. 2022).

For many years, some countries have had electronic documentation systems in which claw lesions are recorded at each hoof-trimming visit. In contrast to Scandinavian countries, the Netherlands and Spain (Kujala et al. 2009; Sandgren et al. 2009; Van der Linde et al. 2010; Charfeddine & Pérez-Cabal 2017; Thomsen et al. 2019), there was no centralized collection of claw health data in Austria until October 2017, when Rinderzucht AUSTRIA (www.rinderzucht.at/) initiated the project 'Klauen-Q-Wohl' ('KQW') (ZAR 2017). From the mid-2000s, the use of pen and paper to record claw lesions during hoof trimming (Murray et al. 1996) was increasingly replaced by computer programs that enable hoof-trimming professionals to document electronically and immediately analyse claw health data (Kofler et al. 2011; Sadiq et al. 2020). Several electronic documentation systems are now on the market (Wenz & Giebel 2012; Kofler 2013; Jury et al. 2021), with the program 'Klauenmanager' (SEG Informationstechnik GmbH, Bad Ischl, Austria) widely used in Austria (Kofler et al. 2022, 2023).

Our goal was to evaluate electronically documented claw health data of Austrian dairy cows from 2010 to 2019 and to calculate the cumulative incidence of claw lesions, with a special focus on 'alarm' lesions. We also investigated whether the data show any relationships between incidence and type of claw lesions and lactation number, lactation month, housing type and breed.

Material and Methods

Terminology and documentation program

The basis for the electronic documentation of claw lesions by the hoof trimmers was the terminology published in the ICAR Claw Health Atlas and its two appendices (Egger-Danner et al. 2015; Kofler et al. 2020a,b). Claw trimming data were recorded by hoof trimmers from 2010–2019 and documented electronically with the 'Klauenmanager' program at each hoof-trimming visit to the farms. Using touchscreens, claw lesions can be individually documented according to localization (at 10 claw zones) on the claw of each limb and the program can register 18 different claw lesions, almost each graded by three severity scores (Kofler et al. 2011, 2023).

Data validation

The data sets were centrally collected and stored by ZuchtData (ZuchtData EDV-Dienstleistungen GmbH, Vienna, Austria). For the evaluation, only data from hoof trimmers who had undergone basic and advanced training courses and who had been trained in the use of the tablets and the documentation software were considered. The hoof trimmers achieved a weighted kappa value above the critical limit of 0.61 (95 % confidence interval was 0.64–0.92) (Kofler et al. 2022) on an interobserver reliability test performed online using the SurveyMonkey® program (San Mateo, CA, USA) for the correct diagnosis of 50 different claw lesions, indicating significant to almost perfect agreement (Landis & Koch 1977). This ensured comparability and quality of the data.

Data sets from the years 2010 to 2019 were available, recorded by 32 hoof trimmers. The anonymized data sets were validated and pre-selected according to published guidelines (correct animal identity assignment, correct use of diagnostic codes, plausibility checks) (ICAR 2022). Only data sets that met the following criteria were used:

- Data from the years 2010–2019 exclusively from Austrian dairy herds and exclusively from trained hoof trimmers who had participated in the 'KQW' project; data from farm veterinarians were not used,
- data from all hoof-trimming visits to the dairy herds over the course of one year, i.e., from visits where at least 50 % of cows, based on the mean number of cows per farm, were trimmed and also from visits where only individual animals were trimmed,
- the centrally submitted data sets from these hoof trimmers had to include at least five different claw lesions/diagnoses,
- the data for each farm and hoof trimmer had to include cattle without claw lesions (healthy claws).

The data sets were submitted to the authors by ZuchtData (ZuchtData EDV-Dienstleistungen GmbH, Vienna, Austria) in anonymized form, thus no conclusions could be drawn about the names of the hoof trimmers or the dairy farms. After completion of the validation from originally 627 farms, we evaluated the data sets of 526 dairy farms with 28,638 cattle recorded by 31 hoof trimmers. The records of one hoof trimmer were excluded because he had not completed the interobserver reliability test. Further animal- and farm-related data such as breed [Brown Swiss, Fleckvieh (dual purpose Simmental), Holstein Friesian], housing type (tie stalls, loose housing systems), lactation number and calving dates were also provided by ZuchtData. ZuchtData is responsible for the central cattle database 'RDV' and thus the storage and processing of herd book, performance test and relevant farm information. These records were routinely available. Lactation months and days in milk (DIM) were calculated from dates of calving.

Computation of incidences and relative frequencies of claw lesions

We calculated the incidences of the various claw lesions over the observation period 2010–2019 as follows: for each hoof-trimming visit, each claw lesion per animal was counted only once, even if the same lesion was documented on several claws of a particular animal, and each lesion was counted only once per year. The number of claw lesions per year and herd was summed and divided by the mean number of cows per farm to give the incidence per farm and year. The mean incidence over the entire observation period was then calculated from the mean values of the incidences per farm and year using the following formula:

$$IR = \frac{1}{10} \times \sum_{year=2010}^{2019} \frac{New\ case\ of\ a\ specific\ claw\ lesion\ per\ hoof\ trimming\ visit}{Mean\ number\ of\ cows\ in\ the\ herd\ within\ year}$$

In calculating the cumulative incidence of DD at the animal level, only endemically DD-infected farms were considered, i.e., herds in which at least one DD lesion per cow (early stage: M1, acute stage: M2, chronic stage: M4 & M4.1) (Kofler et al. 2020a) were documented during the observation period.

The individual claw lesions were grouped as follows:

- 'Alarm' lesions: all claw disorders always associated with pain and lameness, such as SU, TU, TN, bulb ulcer (BU), WLA, IP, swelling of coronet and/or bulb

(SW), infected axial horn fissure (HFA), the acute (M2) stage of DD and all DD-associated CHDL.
– Other claw lesions (OTHER): all other claw lesions and claw deformities that are often not associated with lameness: CD, SH, DS, TS, vertical and horizontal horn fissure, interdigital dermatitis, interdigital hyperplasia and corkscrew, scissor, and asymmetric claws.

We defined a healthy claw as a claw free of lesions. Furthermore, diffuse and circumscribed sole haemorrhages were defined as sole haemorrhage (SH), white-line-disease (score 1) as WLD, white-line-abscess (score 2 & 3 of WLD) as WLA, and all cutaneous (early, acute, and chronic) stages of digital dermatitis as DD.

Statistical analysis

Data were analysed using R software (version 3.6.3; R Core Team 2021). We defined the mean cow number as the mean number of feeding days of all dairy cows on a farm (Kofler et al. 2022). Farm incidences for all claw lesions were calculated for each year by removing repeated observations for the same claw lesion and animal and dividing the number of observations for each claw lesion by the mean cow number as defined previously.

We analysed the relationships between the farm incidence of certain claw lesions with the influencing factors year, hoof trimmer, number of trimming events per herd, housing type and breed by logistic regression using a mixed linear model with random effect of the farm and a logit link function (R function 'lmer' from the package lme4, version 1.1-21). Least square means and Tukey-adjusted P values of pairwise differences were given by the R package ls-means, version 2.30-0. We considered a relationship statistically significant if p was <0.05.

To analyse the associations between the incidence of specific claw lesions with the lactation number and the lactation month at the individual animal level, we used logistic regression with a logit link function and a mixed linear model (R function 'glmer' from the package lme4, version 1.1-21), combining multiple lesions (of the same type) on different limbs of a single animal on a given date into a single lesion. In addition to the target effect lactation number (0 to 8+, where 0 stands for heifers and 8+ for eight or more lactations) and lactation month (1–12, where lactation months >12 were excluded), we modeled a random animal effect. Both lactation number and lactation month were modeled as continuous covariates. The relevance of the effects, expressed as change in estimated incidence from first to lactation 8+ and from first to 12th lactation month, was derived using the 95 % confidence intervals, as significance tests are often not meaningful with large data sizes. A confidence interval >0 for the change in incidence indicates an increase in the incidence of the claw lesions with lactation number or lactation month.

Ethical approval

The study was reviewed and endorsed by the Ethics and Animal Welfare Committee of the University of Veterinary Medicine Vienna and complies with Good Scientific Practice and national legislation (ETK-017/07/2020).

Results

Of the evaluable data sets, 95 % came from dairy farms in the provinces of Styria and Lower Austria, the remaining 5 % from farms in Upper Austria and Carinthia. The mean age of all dairy cows during the observation period was 5.1 years (±4.8). The cows were Fleckvieh (62.7 %), Holstein Friesian (28.1 %), Brown Swiss (6.6 %) and other breeds (2.6 %).

Frequency of annual herd trimming visits and timing of hoof trimming

Herd hoof-trimming visits (more than 50 % of the mean number of cows per farm were trimmed per visit) were performed once on 43.8 %, twice on 30.8 % and three times per year on 11.3 % of farms. The remaining farms (14.1 %) had four or more trimming visits per year, although only a few animals were trimmed each visit.

Analysis of the data from 28,638 cattle from 526 dairy farms over the ten-year observation period showed that only 12.4 % of the cows were hoof-trimmed at dry-off (approximately at 305 DIM), while 28.3 % of cows were trimmed during their first 100 DIM and the remaining 59.3 % between 101 and 305 DIM. About 50 % of the professional hoof trimmers performed trimming on a mean of 55.7 % of cows per farm per visit, although there was a considerable variation (Fig. 1). The data sets showed no significant correlations between the lactation number and the number of hoof trimmings per year; the Pearson correlation coefficient was $r=0.069$ ($p\geq0.05$).

Incidences of claw lesions at animal and herd level

The percentage of cows with at least one claw lesion (including severity score 1-lesions) per hoof-trimming visit was above 70 % for farms of each size group, with an average of 82.2 % (Fig. 2). Farms with fewer than 70 cows showed a variation of 10 to 90 %, suggesting that a large proportion of the herd was trimmed in herds with a lower percentage of documented claw lesions on some visits. On other visits, only claws from single, lame animals were trimmed in herds in which the percentage of lesions and their severity scores were significantly higher (Fig. 2).

On average, the claws of 17.8 % (±21.5) of cows were free of lesions and 74.1 % (±29.0) of the individual claws (eight claws per cow) of the animals were without lesions. Table 1 lists the incidences of claw lesions

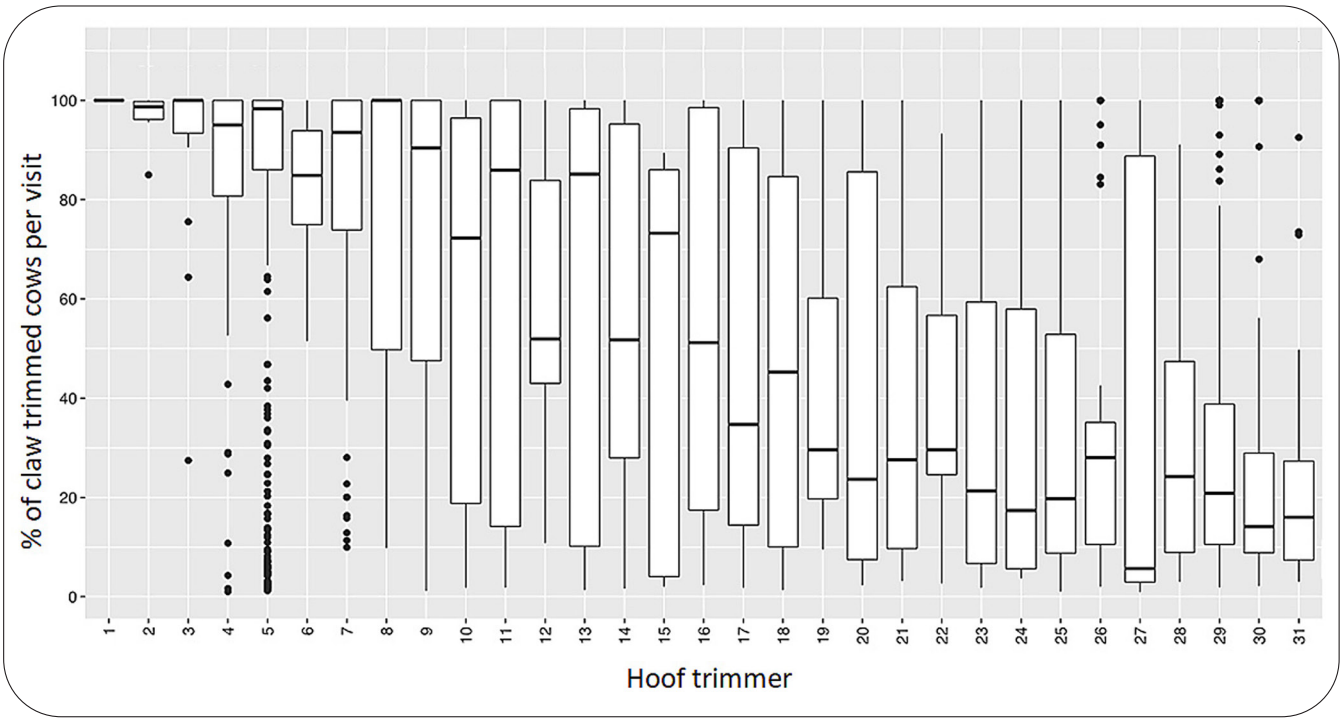


Fig. 1: Boxplot graph of the percentage of hoof-trimmed cows of the mean number of cows per farm and per hoof-trimming visit for the 31 hoof trimmers (anonymized) during the observation period 2010–2019; 31 hoof trimmers, 526 farms / Boxplotdarstellung des Prozentsatzes der Rinder, bei denen eine Klauenpflege vorgenommen wurde, bezogen auf die durchschnittliche Zahl von Kühen je Betrieb und pro Besuch der 31 Klauenpfleger (anonymisiert) während des Beobachtungszeitraums 2010–2019; 31 Klauenpfleger, 526 Betriebe.

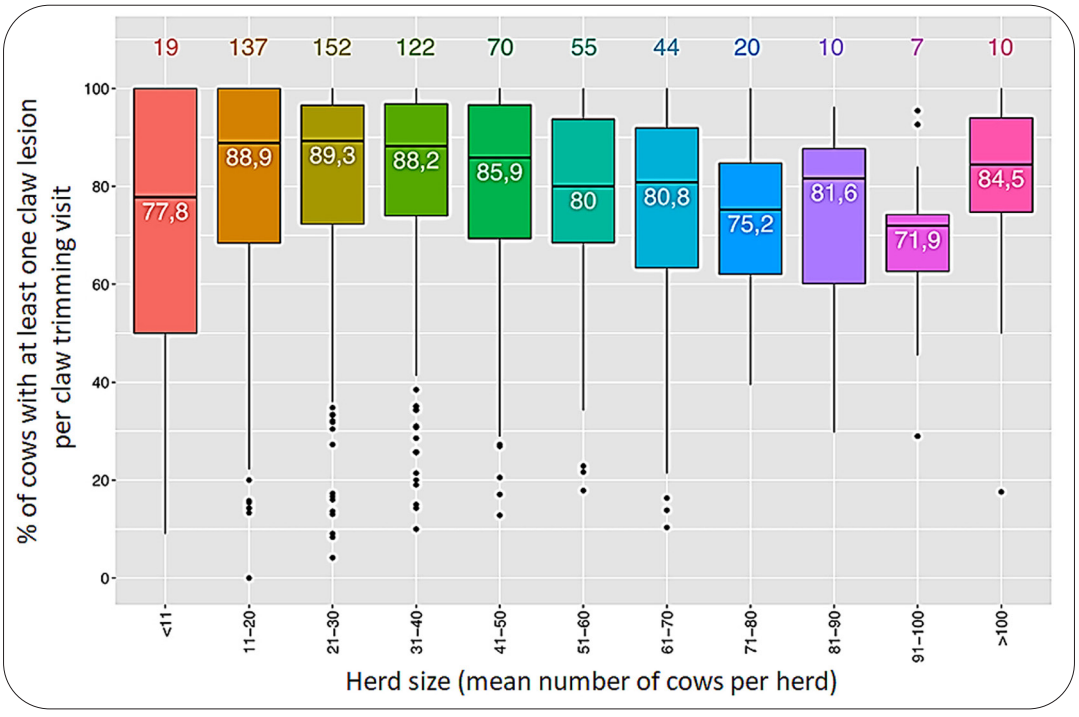


Fig. 2: Boxplot graph of the percentage of cows with at least one claw lesion (i.e., all findings except claws without any lesions) per hoof-trimming visit ordered by herd size over the years 2010–2019. The number above each box denotes the number of farms in the herd size categories listed in the x axis (a farm could fall into more than one group if its size changed over the observation period). The white number and the black line within each box denote the median; 526 farms. / Boxplotdarstellung des Prozentsatzes der Rinder mit zumindest einer Klauenläsion (d.h. alle Befunde außer Klauen ohne jegliche Läsion) je Klauenpflegetermin, nach Herdengröße geordnet, für die Jahre 2010–2019. Die Zahl über der Box gibt die Anzahl der Betriebe mit der in der x-Achse angegebenen Herdengröße an (ein Betrieb kann in mehreren Kategorien vorkommen, wenn sich die Bestandsgröße während des Beobachtungszeitraums geändert hat). Die weiße Zahl und der schwarze Strich in der Box zeigen den Medianwert an; 526 Betriebe.

Tab. 1: List of mean incidences (%) of individual claw lesions with all three severity scores per lesion from 2010–2019. Data set is at the cow level (on at least one claw) in percent with standard deviation (SD) and median value (median); Digital dermatitis (DD) denotes early (M1, <2 cm), acute (M2, >2 cm) and chronic (M4, M4.1) stages; 417,489 claw lesions; 28,638 cattle on 526 farms; values for DD refer only to the 285 farms endemically infected with DD during the observation period; the term 'alarm' lesions include all claw disorders always associated with pain and lameness, such as SU, TU, TN, BU, WLA, IP, SW, HFA, the acute (M2) stage of DD, and all DD-associated CHDL. / Durchschnittliche Inzidenzen (%) der einzelnen Klauenläsionen unter Berücksichtigung der drei Schweregrade je Läsion für die Jahre 2010–2019. Die Inzidenzen beziehen sich auf Einzeltierebene (mindestens eine Läsion) in % mit der Standardabweichung (SD) und dem Median (median); Digitale Dermatitis (DD) umfasst frühe (M1, <2 cm), akute (M2, >2 cm) und chronische (M4, M4.1) Stadien; 417.489 Klauenläsionen; 28.638 Rinder in 526 Betrieben; Ergebnisse für DD beziehen sich nur auf die 285 Betriebe, die während des Beobachtungszeitraums endemische DD-Infektionen aufwiesen; der Ausdruck „'Alarm' lesions" schließt alle mit Schmerz und Lahmheit einhergehenden Klauenerkrankungen ein, also SU, TU, TN, BU, WLA, IP, SW, HFA, akute (M2) Stadien der DD, und alle DD-assoziierten CHDL.

Type of claw lesion	mean	SD	median	mean score 1	mean score 2	mean score 3
Heel horn erosion (HHE)	59.2	32.6	52.6	47.8	3.1	2.6
White-line-disease (WLD)	42.6	30.6	41.1	42.6	-	-
White-line-abscess (WLA)	3.4	7.0	0.0	-	2.2	1.2
Sole haemorrhage (SH)	28.3	24.3	23.1	21.6	3.9	2.8
Concave dorsal wall (CD)	16.8	10.6	14.1	11.4	4.2	2,2
Double sole (DS)	14.5	14.1	11.0	7.2	4.1	3.2
Sole ulcer (SU)	11.9	11.7	8.4	7.7	2.3	1.9
Toe ulcer (TU)	0.8	2.0	0.0	0.6	0.2	0.0
Toe necrosis (TN)	0.1	0.1	0.0	-	-	0.1
Bulb ulcer (BU)	1.4	2.8	0.0	0.8	0.3	0.3
Ulcers (in all locations)	**14.2**	**13.0**	**10.4**			
Horn fissure (HF)	2.1	4.8	0.0	0.5	1.1	0.5
Horn fissure axial (HFA)	0.7	2.5	0.0	-	-	0.7
Horn fissure horizontal (HFH)	0.1	0.4	0.0	-	-	0.1
Thin sole (TS)	0.2	0.6	0.0	-	0.2	-
Digital dermatitis (DD)	29.6	25.9	26.9	5.6 (early)	12.8 (chronic)	11.2 (acute)
Interdigital dermatitis (ID)	0.3	1.1	0.0	-	-	0.3
Interdigital phlegmon (foot rot) (IP)	0.7	1.5	0.0	0.5	0.1	0.1
Swelling of coronet and/or bulb (SW)	0.9	2.7	0.0	0.2	0.6	0.1
Interdigital hyperplasia (IH)	5.1	8.7	2.0	4.0	1.5	0.5
Corkscrew claw (CC)	8.6	14.8	2.0	-	-	-
Scissor claw (SC)	2.6	8.1	0.0	-	-	-
Asymmetric claw (AC)	4.7	9.6	0.0	-	-	-
'Alarm' lesions	**29.5**	**19.3**	**24.2**	-	-	-

diagnosed during the observation period and the distribution of their severity scores. Severity scores 1 were the most frequent for many claw lesions, with mean incidences of 59.2 % (±32.6) for heel horn erosion (HHE), 42.6 % (±30.6) for WLD, 28.2 % (±24.3) for SH, 29.6 % (±25.9) for DD, 14.5 % (±14.1) for DS and 14.2 % (±13.1) for ulcers at all sole sites. There was a large variation of the individual claw lesions between farms. The mean incidences of deformed claws, such as corkscrew, scissor and asymmetric claws, ranged from 2.6 % (±8.1) to 8.6 % (±14.8).

The mean incidence of 'alarm' lesions was 29.5 % (±19.3) (Table 1). The most common painful disorders included in these 'alarm' lesions were ulcers (mean incidence of 33.9 %; at all sole sites), acute stage (M2) of DD (mean incidence of 33.2 %) and white-line-abscesses (mean incidence of 17.4 %). Other 'alarm' lesions had significantly lower mean incidences of ≤3.8 % (Fig. 3).

In 29.7 % to 54.2 % herds on the 526 dairy farms DD was endemic during 2010 to 2019. The DD herd prevalence in 2019 was 48.9 %. At least one DD lesion was documented in 285 of the 526 farms (54.2 %)

from 2010 until end of 2019, so the remaining farms could be considered DD-free up to the end of 2019. In the cows on the 285 farms with endemic DD infection, cutaneous stages of DD predominated, compared with DD-associated CHDL (85.2 vs. 14.8 %). The majority of cutaneous DD lesions (69.4 %) were in claw zone 8 (skin over the bulbs), followed by zone 7 (skin in the interdigital space) with 29.8 % and zone 9 (skin over the coronary band dorsally and abaxially) with 0.8 %. The most frequent DD-associated CHDL were DD-associated white-line-abscesses (54.2 %), followed by DD-associated sole ulcers (32.5 %), DD-associated toe ulcers/toe necroses (6.2 %) and DD-associated (axial) horn fissures (3.7 %) (Table 1).

Relationships between incidence of claw lesions, lactation number, and lactation month

Data analysis at the individual animal level found significantly higher ($p<0.001$) incidences of CD, SH, SU, WLD, WLA, HHE and 'alarm' lesions with increasing lactation number. In contrast, the incidences of other claw lesions (BU, TU, TN, SW, IP) changed only insignificantly across lactations, while there was a significant reduction ($p<0.001$) in the incidence of DD with increasing lactation number (Figs. 4, 5). More than a third (37.3 %) of heifers (lactation 0), 30.2 % of first lactation cows and 29.6 % of second lactation cows were affected by DD; the incidence of DD in lactation 8+ was only 15.7 % (Fig. 8). The incidence of DD-infected cattle ranged from 22.3 % to 35.2 % over the observation period on the 285 farms.

Interdigital phlegmon was more frequent shortly after calving and up to the second month of lactation, and DD was more frequent in the first four months of lactation (Figs. 6, 7). Concave dorsal walls, sole haemorrhages, sole and bulb ulcers, and 'alarm' lesions were significantly more common ($p<0.001$) in lactation months 2 to 8, while the incidence of other claw lesions did not change significantly across lactation months (Figs. 6, 7). The incidence of DD at the animal level decreased significantly ($p<0.001$) with increasing lactation number, with heifers (lactation 0) most commonly affected at 37.3 %, first lactation cows at 30.2 % and second lactation cows at 29.6 %; the incidence of DD in lactation 8+ was only 15.7 % (Fig. 8).

Differences in incidences with herd size, housing type, and breed

The DD incidence at the animal level showed a moderately positive correlation ($r=0.38$, $p<0.001$) with the mean cow number in the herds, although the coefficient was driven by the few larger herds (mean cow number > 100). For the other claw lesions, the correlation with the mean cow number per farm was lower ($r \leq 0.16$) and not significant.

There were significant differences in the incidence of some claw lesions in different types of housing (tie stalls, loose housing systems). The mean incidence of all claw lesions was 85.3 % in cows kept in loose housing systems, but it was significantly lower (79.6 %, $p<0.05$) in tie stalls (Fig. 9a,b). Cows kept in tie stalls were significantly more likely to have ulcers (all locations combined), with an incidence of 24.4 % ($p<0.01$), and SU, with an incidence of 22.8 % ($p<0.001$), whereas WLD was significantly more frequent (48.2 %, $p<0.001$) in cows in loose housing systems compared with cows kept in tie stalls (35.2 %, Fig. 9a,b). Other claw lesions (OTHER) were also significantly more frequent in cows kept in loose housing systems (37.4 %) than in cows kept in tie stalls (28.0 %). The incidences of TU, SW, DD, HFA and 'alarm' lesions showed no significant differences between the two housing types.

Fig. 10 shows the main results of the mixed linear model of differences in the incidences of some claw lesions between the three main breeds. Considering all claw lesions together, there were significant differences ($p<0.001$) in the incidences be-

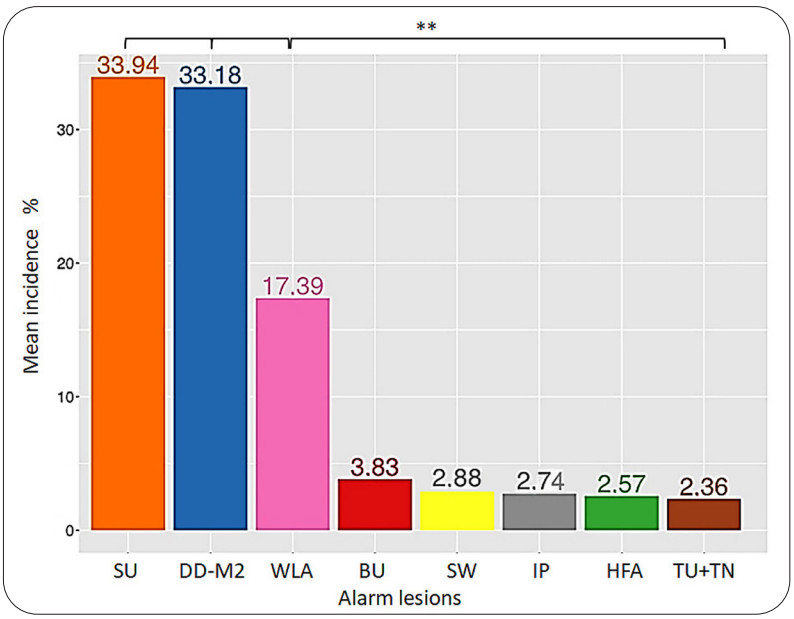


Fig. 3: Distribution of mean incidence of painful 'alarm' lesions on farms during the observation period 2010–2019; SU = sole ulcer; DD-M2 = acute digital dermatitis (M2) lesion; WLA = white-line-abscess; BU = bulb ulcer; SW = inflammatory swelling of the coronet and bulb; IP = interdigital phlegmon (foot rot); HFA = infected axial horn fissure; TU+TN = toe ulcer and toe necrosis; 526 farms. / Verteilung der durchschnittlichen Inzidenz schmerzhafter Alarmläsionen in den Betrieben im Beobachtungszeitraum 2010–2019; SU = Sohlengeschwür; DD-M2 = akute Dermatitis digitalis (M2) Läsion; WLA = Weiße-Linie-Abzeß; BU = bulb ulcer; SW = Kronsaum- und Ballenschwellung; IP = Zwischenklauenphlegmone (foot rot); HFA = infizierter axialer Hornspalt; TU+TN = Sohlenspitzengeschwür und Sohlenspitzennekrose; 526 Betriebe.

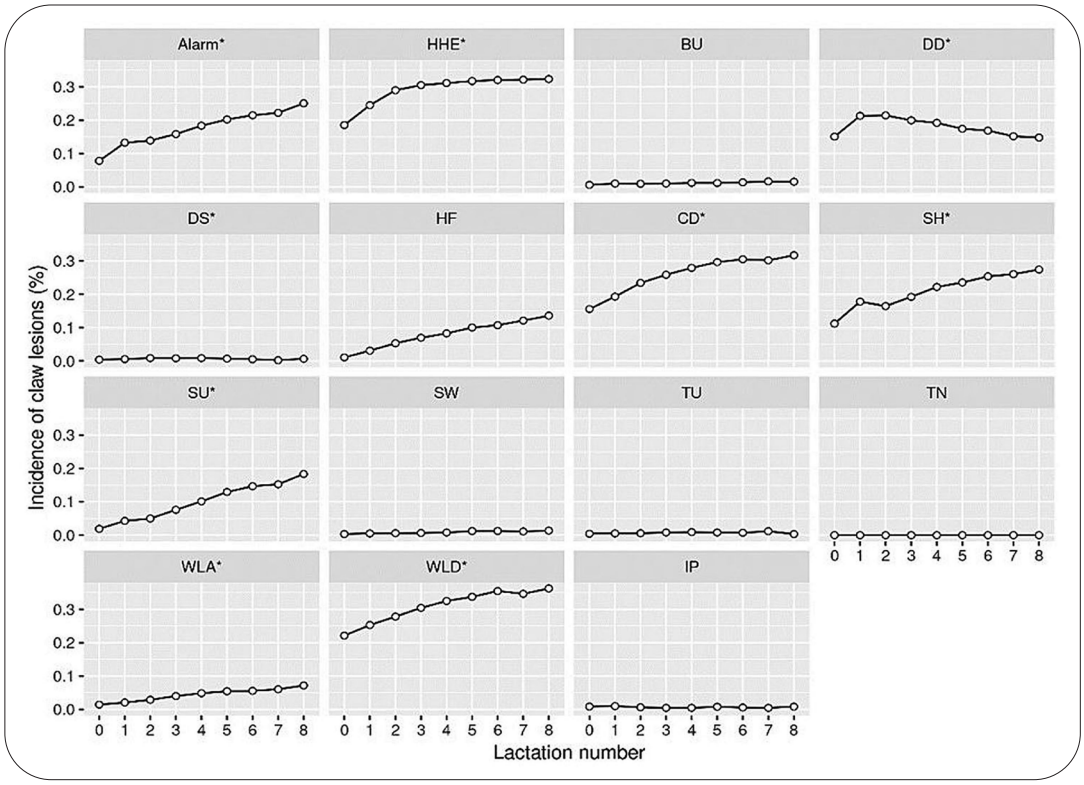


Fig. 4: Incidence of claw lesions by lactation number (lactation number 0 = heifers); Alarm = 'alarm' lesions; HHE = heel horn erosion; BU = bulb ulcer; DD = digital dermatitis; DS = double sole; HF = horn fissure; CD = concave dorsal wall; SH = sole haemorrhage; SU = sole ulcer; SW = swelling of coronet and bulb of the heels; TU = toe ulcer; TN = toe necrosis; WLA = white-line-abscess; WLD = white-line-disease; IP = interdigital phlegmon; significant effects ($p<0.05$) are indicated by asterisks; 28,391 cattle on 525 farms / Inzidenz von Klauenläsionen in Bezug auf die Anzahl der Laktationen (Laktation 0 = Kalbinnen); Alarm = Alarmläsionen; HHE = Ballenhornfäule; BU = Ballengeschwür; DD = Dermatitis digitalis; DS = Doppelsohle; HF = Hornspalt; CD = konkave Vorderwand; SH = Sohlenblutung; SU = Sohlengeschwür; SW = Kronsaum- und Ballenschwellung; TU = Sohlenspitzengeschwür; TN = Sohlenspitzennekrose; WLA = Weiße-Linie-Abszeß; WLD = Weiße-Linie-Defekt; IP = Zwischenklauenphlegmone; signifikante Effekte ($p<0,05$) sind mit Sternchen gekennzeichnet; 28.391 Rinder in 525 Betrieben.

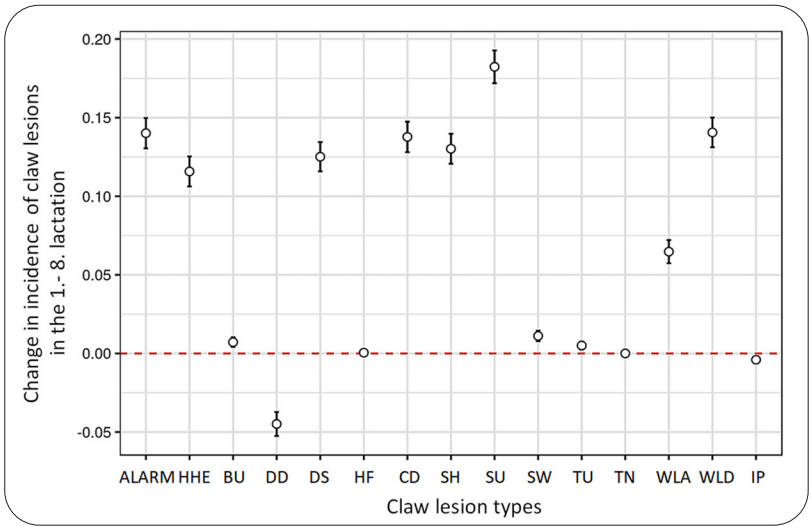


Fig. 5: 95 % confidence intervals (CI) of the change in incidence of claw lesions in the 1st–8th lactation. Increases (values above dashed line) or decreases (values below dashed line) in incidence are significant ($p<0.05$) if the 95 % CI does not include the value 0. ALARM = 'alarm' lesions; HHE = heel horn erosion; BU = bulb ulcer; DD = digital dermatitis; HF = horn fissure; CD = concave dorsal wall; SH = sole haemorrhage; SU = sole ulcer; SW = swelling of coronet and bulb of the heels; TU = toe ulcer; TN = toe necrosis; WLA = white-line-abscess; WLD = white-line-disease; IP = interdigital phlegmon; 28,391 cattle in 525 farms / 95 % Konfidenzintervalle der Änderung der Inzidenz von Klauenläsionen von der ersten bis zur 8. Laktation. Anstiege (Werte über der gestrichelten Linie) oder Verringerungen (Werte unter der gestrichelten Linie) der Inzidenz sind statistisch signifikant verschieden, wenn das 95 % Konfidenzintervall den Wert „0" nicht enthält. ALARM = Alarmläsionen; HHE = Ballenhornfäule; BU = Ballengeschwür; DD = Dermatitis digitalis; HF = Hornspalt; CD = konkave Vorderwand; SH = Sohlenblutung; SU = Sohlengeschwür; SW = Kronsaum- und Ballenschwellung; TU = Sohlenspitzengeschwür; TN = Sohlenspitzennekrose; WLA = Weiße-Linie-Abszeß; WLD = Weiße-Linie-Defekt; IP = Zwischenklauenphlegmone; 28.391 Rinder in 525 Betrieben.

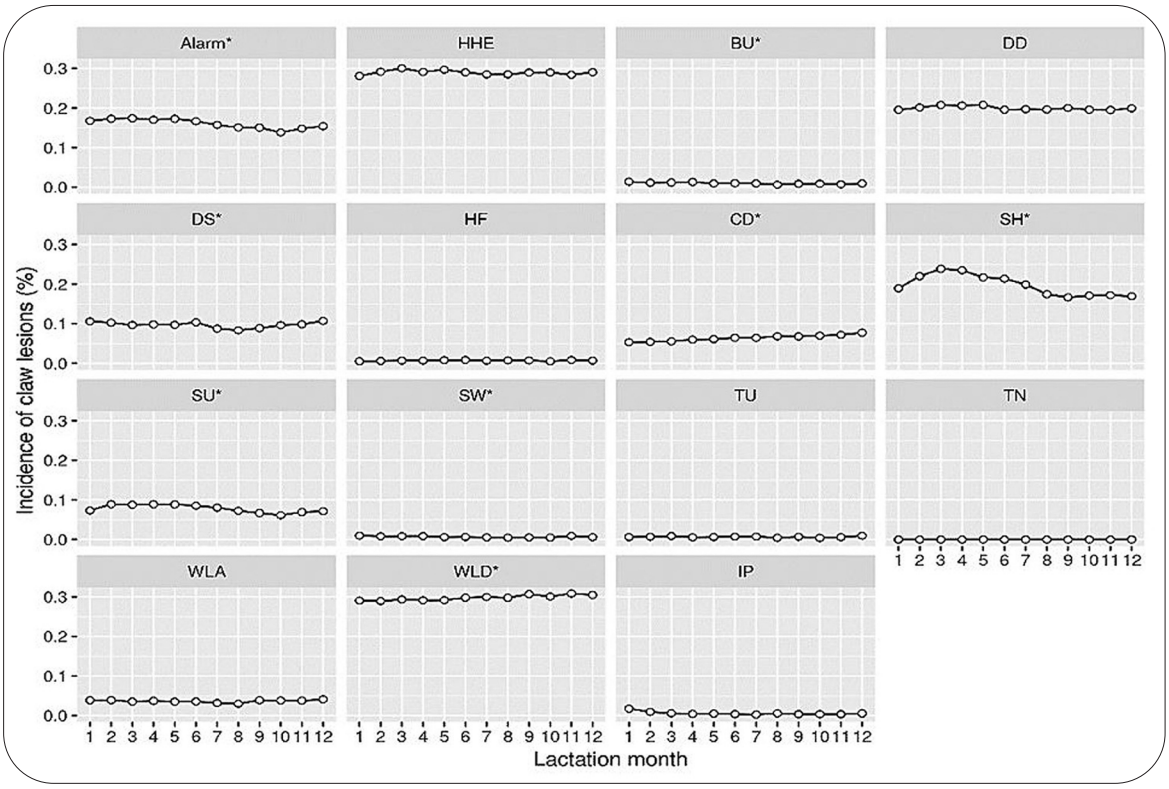
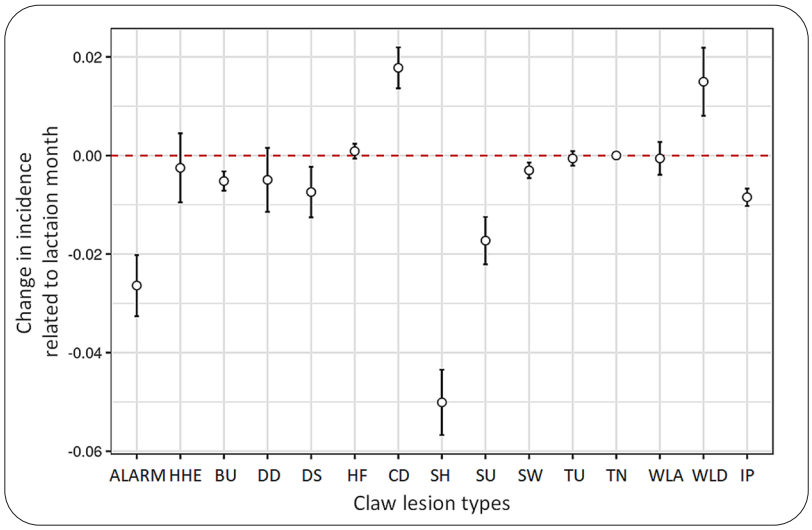


Fig. 6: Incidence of claw lesions related to lactation month; Alarm = 'alarm' lesions; HHE = heel horn erosion; BU = bulb ulcer; DD = digital dermatitis; DS = double sole; HF = horn fissure; CD = concave dorsal wall; SH = sole haemorrhage; SU = sole ulcer; SW = swelling of the coronet and bulbs of the heel; TU = toe ulcer; TN = toe necrosis; WLA = white-line-abscess; WLD = white-line-disease; IP = interdigital phlegmon; significant effects ($p<0.05$) are indicated by asterisks; n: 25,590 cattle on 526 farms / Inzidenz von Klauenläsionen in Bezug auf den Laktationsmonat; Alarm = Alarmläsionen; HHE = Ballenhornfäule; BU = Ballengeschwür; DD = Dermatitis digitalis; DS = Doppelsohle; HF = Hornspalt; CD = konkave Vorderwand; SH = Sohlenblutung; SU = Sohlengeschwür; SW = Kronsaum- und Ballenschwellung; TU = Sohlenspitzengeschwür; TN = Sohlenspitzennekrose; WLA = Weiße-Linie-Abszeß; WLD = Weiße-Linie-Defekt; IP = Zwischenklauenphlegmone; signifikante Effekte ($p<0,05$) sind durch Sternchen gekennzeichnet; 25.590 Rinder in 526 Betrieben.

Fig. 7: 95 % confidence intervals of the change in incidence of claw lesions of the 1st–10th month of lactation. Increases (values above dashed line) or decreases (values below dashed line) in incidence are significant ($p<0.05$) if the 95 % CI does not include the value 0. ALARM = 'alarm' lesions; HHE = heel horn erosion; BU = bulb ulcer; DD = digital dermatitis; DS = double sole; HF = horn fissure; CD = concave dorsal wall; SH = sole haemorrhage; SU = sole ulcer; SW = swelling of the coronet and bulbs of the heel; TU = toe ulcer; TN = toe necrosis; WLA = white-line-abscess; WLD = white-line-disease; IP = interdigital phlegmon; 25,590 cattle; 526 farms / 95 % Konfidenzintervalle der Änderung der Inzidenz von Klauenläsionen vom ersten bis zum 10. Monat der Laktation. Anstiege (Werte über der gestrichelten Linie) oder Verringerungen (Werte unter der gestrichelten Linie) der Inzidenz sind statistisch signifikant verschieden, wenn der 95 % Konfidenzintervall den Wert „0“ nicht enthält. ALARM = Alarmläsionen; HHE = Ballenhornfäule; BU = bulb ulcer; DD = Dermatitis digitalis; DS = Doppelsohle; HF = Hornspalt; CD = konkave Vorderwand; SH = Sohlenblutung; SU = Sohlengeschwür; SW = Kronsaum- und Ballenschwellung; TU = Sohlenspitzengeschwür; TN = Sohlenspitzennekrose; WLA = Weiße-Linie-Abszeß; WLD = Weiße-Linie-Defekt; IP = Zwischenklauenphlegmone; 25.590 Rinder; 526 Betriebe.



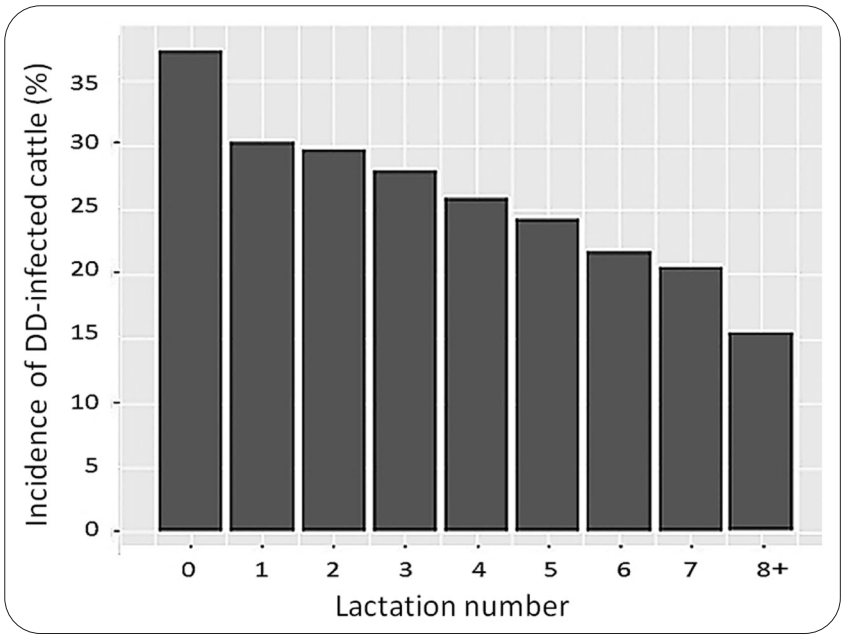


Fig. 8: Incidence of DD-infected cattle by lactation number; DD = digital dermatitis; 285 farms / Inzidenz der DD-infizierten Rinder nach Laktationsperiode; DD = Dermatitis digitalis; 285 Betriebe.

tween Brown Swiss and Fleckvieh and between Brown Swiss and Holstein Friesian cows but not between Fleckvieh and Holstein Friesian cows. Fleckvieh cows had the highest incidence of claw lesions (89.5 %), followed closely by Holstein Friesian (87.4 %) and Brown Swiss cows (72.1 %). 'Alarm' lesions (44.3 %) and DD (42.1 %) were significantly more frequent ($p<0.05$) in Holstein Friesian cows than in other breeds. Fleckvieh cows had the highest incidence of WLD (58.7 %), other claw lesions (38.6 %; OTHER) and SH (37.5 %). There were statistically significant differences in incidences of 'alarm' lesions between Brown Swiss and Holstein Friesian cows ($p<0.01$) and between Fleckvieh and Holstein Friesian cows ($p<0.05$) but not between Brown Swiss and Fleckvieh cows. There were statistically significant differences ($p<0.001$) in SH between Brown Swiss and Fleckvieh cows but not between Fleckvieh and Holstein Friesian cows. Incidences of WLD were significantly ($p<0.001$) higher in Fleckvieh cattle at 58.7 % than in Holstein Friesian at 32.3 % and Brown Swiss cows at 13.2 %, while incidences of DD were significantly ($p<0.001$) higher in Holstein Friesian cows at 42.1 % than in Fleckvieh cows at 23.3 %, and significantly ($p<0.01$) higher than in Brown Swiss cows at 13.1 % (Fig. 10). All other claw lesions (DS, DUN, HF, IH, CD, CC, SC, AC) were rare and were almost equally distributed among the three main breeds.

Discussion

In contrast to recent studies of claw health data over a single year (Kujala et al. 2009; Thomsen et al. 2019; Kofler et al. 2022), we evaluated claw health data over a ten-year period. Other researchers have used similar methodologies to investigate claw lesion data from a four-year timeframe (Arango-Sabogal et al. 2020) and data from separate four- and eight-year timeframes were used to calculate the heritability of claw lesions in dairy cows (Van der Linde et al. 2010; Ødegård et al. 2013). Our analysis showed that the majority of farms (43.8 %) conducted only one annual herd-trimming visit, with around one-third opting for two visits and only 11.3 % choosing three visits. This highlights a significant gap in understanding among farmers about the preventive benefits of conducting hoof trimming twice or thrice a year in high-yielding dairy herds and should be seen in the context of the rates of claw lesions and mean prevalences of lameness, which range from 27.7 % to 51 % in Austrian dairy herds (Fuerst-Waltl et al. 2021; Kofler et al. 2021, 2022). A further unexpected finding was that only slightly over 12 % of cows were hoof-trimmed around/after 305 DIM, i.e. around dry-off, and slightly under one third of cows were trimmed during their first 100 DIM. Changing management attitudes to align hoof trimming with the stages of a cow's lactation and trimming immediately before dry-off and again between 40 to 60 DIM, as commonly practiced in larger dairy herds (Griffiths et al. 2018; Thomsen et al. 2019), would provide a clear opportunity to enhance claw health in many Austrian dairy herds. The additional costs of more frequent preventive hoof trimming visits are far outweighed by significantly lower costs for treating lame cattle by veterinarians and by higher productivity (Manske et al. 2002; Thomsen et al. 2019; Sadiq et al. 2020). Many Austrian farm managers currently opt for seasonal hoof trimming at six-month intervals. However, hoof trimming at four-month intervals leads to a significant reduction in the odds ratio (OR) for SU (0.59), DS (0.71) and WLD (0.86) (Manske et al. 2002). Hoof-trimming of cows in Denmark around dry-off resulted in a 20 % reduction in the OR for SU in the subsequent lactation (Thomsen et al. 2019). An evaluation of 1,476,013 pregnancies in Danish dairy cows found the lowest risk of abortion (OR=1) with hoof-trimming nine weeks before expected parturition, whereas the OR for abortion with hoof-trimming four weeks before expected parturition was distinctly higher at 2.38 (Thomsen et al. 2020).

One reason for the preferred seasonal hoof-trimming of herds is the generally small size of herds on Austrian dairy farms: the average herd size of about 23.6 cows is substantially lower than in other countries (Rinderzucht AUSTRIA 2022). As a result, seasonal hoof-trimming of all cows, except the ones in

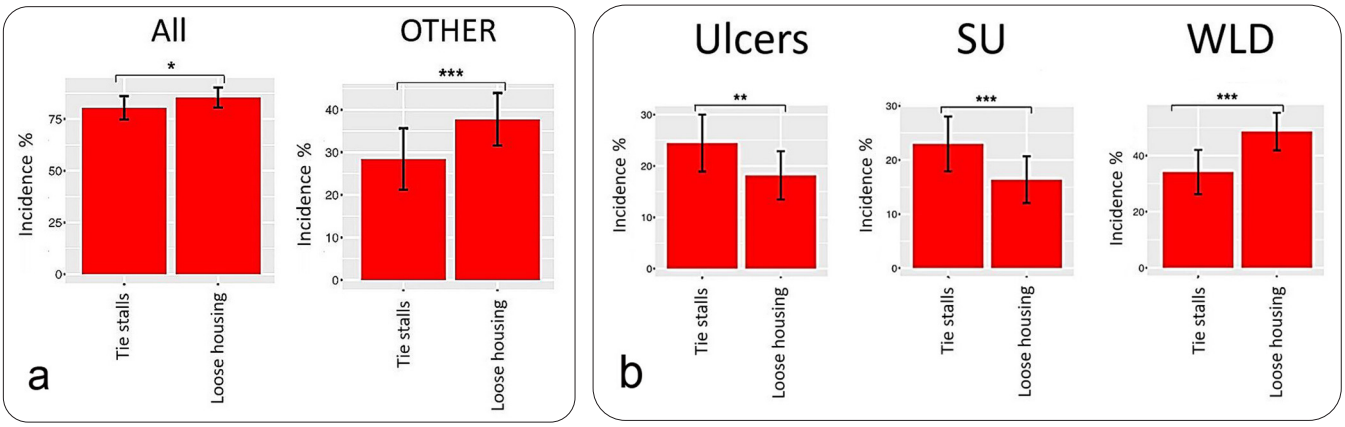


Fig. 9a,b: Results of the mixed linear model to investigate the relationship between incidence of individual claw lesions and the housing types tie stalls (with 90 days of turnout) and loose housing systems; All = all documented claw lesions; OTHER = other claw lesions (all lesions without 'alarm' lesions); Ulcers = all ulcers independent of the location combined; SU = sole ulcer; WLD = white-line- disease; the figures show only claw lesions with significant differences between housing types: ***: p<0.001; **: p<0.01; *: p<0.05; 384 farms / Ergebnisse des gemischten linearen Modells zur Untersuchung des Zusammenhangs zwischen der Inzidenz der Klauenläsionen bei den einzelnen Tieren und Arten der Anbindehaltung (mit 90 Tagen Auslauf/Weidehaltung) und Laufstallsystemen; All: alle erfassten Klauenläsionen; OTHER: andere Klauenläsionen (ohne Alarmläsionen); Ulcers = alle Geschwüre unabhängig von der Lokalisation; SU = Sohlengeschwür; WLD = Weiße-Linie-Defekt; die Abbildungen zeigen nur die Klauenläsionen mit signifikanten Unterschieden zwischen den Rassen: ***: p<0,001; **: p<0,01; *: p<0,05; 384 Betriebe.

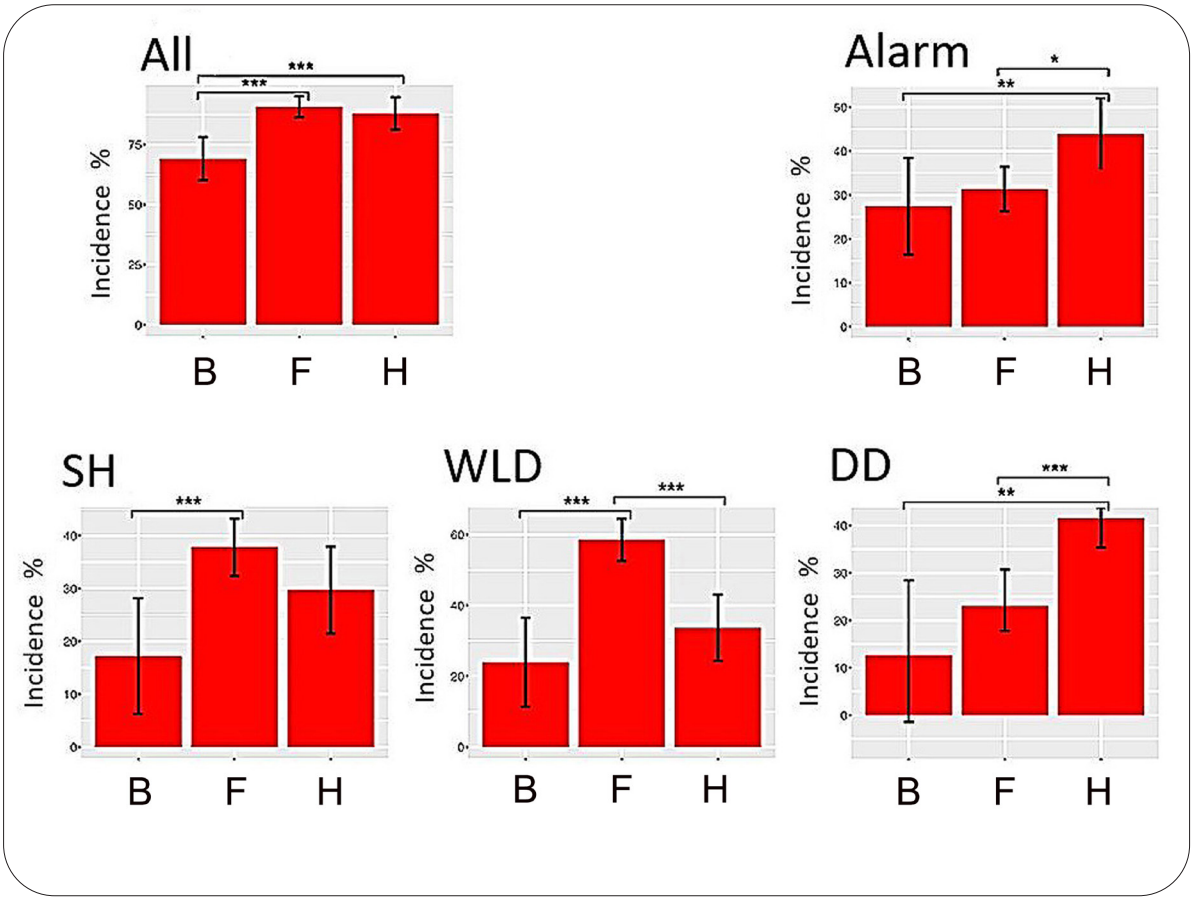


Fig. 10: Results of the mixed linear model investigating the relationship between the incidence of individual claw lesions and the three main breeds: Brown Swiss (B), Fleckvieh (S) and Holstein Friesian (H) on the farms; All = all documented claw lesions combined; Alarm = 'alarm' lesions (claw lesions always associated with pain); SH = sole haemorrhages; WLD = white-line-disease; DD = digital dermatitis; the figures show only claw lesions with significant differences between breeds: ***: p<0.001; **: p<0.01; *: p<0.05; 384 farms / Ergebnisse des gemischten linearen Modells zur Untersuchung des Zusammenhangs zwischen der Inzidenz der Klauenläsionen bei den einzelnen Tieren und den drei Hauptrassen auf den Betrieben: Brown Swiss (B), Fleckvieh (S) und Holstein Friesian (H); All = alle erfassten Klauenläsionen; Alarm = Alarmläsionen (Klauenläsionen, die immer schmerzhaft sind); SH = Sohlenblutungen; WLD = Weiße-Linie-Defekt; DD = Dermatitis digitalis; die Abbildungen zeigen nur die Klauenläsionen mit signifikanten Unterschieden zwischen den Rassen: ***: p<0,001; **: p<0,01; *: p<0,05; 384 Betriebe.

late gestation appears in the first instance to achieve economic benefits for the farmer and the professional hoof-trimmer. This measure can be organized in a more time-saving manner. For herds with a milk yield > 9,000 kg per year, many authors recommend individual trimming thrice a year using a temporal scheme such that each cow is trimmed around dry-off, again between 40 and 60 DIM and a third time around 150 DIM (Manske et al. 2002; Machado et al. 2010; Griffiths et al. 2018; Thomsen et al. 2019; Sadiq et al. 2020; Fuerst-Waltl et al. 2021).

We found that four or more hoof-trimming visits per year were made by approx. 14 % of farms. Based on the documented lesions, only individual cows with mainly painful claw lesions were trimmed on such visits and such therapeutic trimming of lame cows took place consistently as reported also elsewhere (Arango-Sabogal et al. 2020). On such farms, it is imperative that the farm veterinarian convinces farmers to move away from therapeutic hoof-trimming of lame cows and instead to focus on preventive hoof-trimming adapted to the stage of pregnancy and lactation (Thomsen et al. 2019; Arango-Sabogal et al. 2020; Sadiq et al. 2020).

From a strategic perspective, it is notable that cows with higher lactation numbers were not more likely to be hoof-trimmed than younger cows, even though our data showed an increase of CD, SH, SU, WLD, WLA, HHE and 'alarm' lesions with increasing lactation number. Other authors confirm the increase of these laminitis- and pressure-related claw lesions with lactation number (Manske et al. 2002; Fjeldaas et al. 2007; Foditsch et al. 2016). For example, cows in Norway had an OR of 4.8 for pressure-related CHDL from the seventh lactation onwards compared with cows with three or fewer lactations (Fjeldaas et al. 2007). Therefore, preventive hoof-trimming three to four times per year is recommended for cows in higher lactations, which are also much more likely to have chronic laminitis (CD) with all its sequelae (Greenough 2007; DeFrain et al. 2013; Kofler et al. 2023). By adopting shorter trimming intervals, it is possible to treat any claw lesions that arise at an early stage and to equalize the variation in heel height between lateral and medial claws repeatedly. This leads to a notable reduction in the load discrepancy between the outer and inner claws of the hindfeet and minimizes the likelihood of developing (painful) CHDL and its complications (Van der Tol et al. 2002; Oehme et al. 2019; Sadiq et al. 2020).

Many farmers may be unfamiliar with the benefits of aligning hoof-trimming with these critical periods in dairy cows, which pose higher risks to claw health. To facilitate the transfer of these insights, we created an information brochure and shared it with all dairy farmers across Austria through the 'KQW' project (LFI 2021).

Modern electronic documentation systems such as Klauenprofi® and 'Klauenmanager' have become integral tools for professional hoof-trimmers and farmers in numerous Austrian dairy herds. They enable convenient processes, such as sorting animals within the herd based on lactation number and tracking the claw health status of specific groups, for example for cows in their fifth or later lactations (Suntinger 2019; LFI 2021). The most frequently documented claw lesions in the data set were HHE, WLD, DD, SH, CD, DS and ulcers, frequently showing the lowest severity score of 1. Comparably high mean prevalences of claw lesions have been reported in Norwegian and Dutch dairy herds (Sogstad et al. 2005; Fjeldaas et al. 2007; Van der Linde et al. 2010). In contrast, Jury et al. (2021) demonstrated much lower prevalences, except HHE and DD, in 238 Swiss dairy herds. The prevalences, however, were only documented during a single hoof-trimming visit, thus the evaluation did not consider cows that had been trimmed due to lameness outside this single herd-trimming visit, or any claw lesions diagnosed subsequently (Jury et al. 2021).

The steady increase of DD herd prevalence in Austrian dairy herds was alarming. In 2010, about 29 % of herds showed endemic DD infection, but the proportion had risen to 48.9 % by 2019 and an evaluation in 2020 revealed a DD herd prevalence of 55.8 % for Austria (Kofler et al. 2022), which is almost identical to that in Switzerland (55.9 %, Jury et al. 2021). The figures contrast with a prevalence of 15 % in Austria about 15 years ago (Hulek et al. 2010). The enormous rise in DD herd prevalence can be explained by a lack of biosecurity awareness and inadequate biosecurity measures on the part of the farmers, who often fail to take this aspect into account when making purchases (Hulek et al. 2010; Bergsten et al. 2017). In a global context, a DD herd prevalence of about 50 % is not unexpected and many countries with extensive dairy herds have widespread DD infections in over 90 % of all herds (Refaai et al. 2013; Solano et al. 2015).

The 'KQW' project introduced the term 'alarm' lesion in the evaluation of claw lesions. It subsumes all claw disorders that are always associated with pain and therefore with lameness (LFI 2021; Kofler et al. 2022). The use of the term aims to draw the attention of the farmer, hoof trimmer, farm veterinarian and other professionals to the problematic claw disorders in a herd that are certain to have a significant impact on animal welfare and production (Sandgren et al. 2009; Bruijnis et al. 2012; Von Keyserlingk et al. 2012), even though their overall prevalence is usually not the highest (Kofler et al. 2022). We found a mean incidence of 29.5 % for 'alarm' lesions, slightly lower than in the year 2020, although there was a large variation between farms (Kofler et al. 2022). Sole ulcers and the acute DD stage were most frequently represented at about 30 % each and WLA with 17.4 %, while other painful claw disorders occurred at significantly lower rates.

We found a notable proportion of mostly genetically determined claw deformities (Huang et al. 1995; Ødegård et al. 2013; Van Amstel 2017), such as cork-

screw (8.6 %), asymmetric (4.7 %) and scissor (2.6 %) claws. Other studies have found significantly higher prevalences of corkscrew claws at the animal level, e.g., 11 % (Ødegård et al. 2013), 10–24 % (Van Amstel 2017) and 16 % in heifers and 33 % in lactating cows (Cook et al. 2019), whereas a prevalence of only 1.4 % was recently reported in Switzerland (Jury et al. 2021). This Swiss study also found significantly lower prevalences of scissor claws and asymmetric claws (<0.9 %) than we found and than reported in Norway (Fjeldaas et al. 2007).

We found only a moderate correlation (r=0.38) between the mean herd size and DD incidence at animal level. This result may be explained by the large differences in housing conditions, management, hoof-trimming intervals and feeding regimes between the more than 500 farms, which vary greatly regardless of size (Jewell et al. 2019). Other authors have found a significantly higher prevalence of lameness in large herds (74–1,500 cows) than in small herds (Griffiths et al. 2018). There were, however, no differences in lameness prevalence with regard to the herd size in a Canadian study, where the mean number of cows per herd was comparable to that in Austria and cows were kept in both tie stalls and loose housing systems (Jewell et al. 2019). The claw health is instead determined by management measures, animal-friendly walking and lying areas (Sandgren et al. 2009; Von Keyserlingk et al. 2012; Becker et al. 2014a; Griffiths et al. 2018; Jewell et al. 2019), close active monitoring of cows for lameness at approximately two-week intervals (Gundelach et al. 2013; ICAR 2022) and adequate and evidence-based treatment and prevention strategies (Thomas et al. 2015; Ebert et al. 2020, Garvey 2022; Kofler & Altenbrunner-Martinek 2022).

Logistic regression analysis showed a statistically significant effect of lactation number and lactation month on the incidence and type of claw lesions at the individual animal level. The incidences of DD and IP were statistically significantly higher shortly after calving until the second month of lactation, significantly higher in heifers and higher during the first two lactations. In contrast, the incidence at the animal level for DD in cows from the eighth lactation was only half that in heifers, where it was approximately 35 %. The results are consistent with the finding of a significant decrease in the incidence of DD with increasing lactation number (Onyiro et al. 2008; Barker et al. 2009; Refaai et al. 2013) and with the highest incidence of DD and IP in heifers and first-lactation cows and during the period around calving (DeFrain et al. 2013; Solano et al. 2015; Osová et al. 2017). An explanation for the significantly lower DD incidence in cows in higher lactations may be the better immune status of older cows (Refaai et al. 2013). In addition, cows with frequently remitting acute DD stages and cows with DD-associated CHDL for many months, which are therefore chronically lame, are culled earlier than cows without these painful disorders (Onyiro et al. 2008; Ebert et al. 2020). The evident accumulation of DD and IP is remarkable in that only about 12 % and 28 % of all animals in the 526 herds were hoof-trimmed around dry-off and within the first 100 DIM. There was also a significantly higher occurrence of laminitis-related CHDL in the middle and last third of lactation (Greenough et al. 2007; Solano et al. 2015; Jewell et al. 2019).

Logistic regression analysis revealed a significant effect of the type of housing on the incidence and the type of individual claw lesion at the individual animal level. In addition to a statistically significantly higher mean incidence of claw lesions in cows kept in loose housing systems, with 85.3 % compared with 79.6 % for cows kept in ties stalls, WLD was significantly more frequent in cows kept in loose housing systems. In contrast, sole ulcers and all types of ulcers were significantly more frequent in cows kept in tie stalls.

The mean incidence of painful 'alarm' lesions (LFI 2021; Kofler et al. 2022) was at a similar level of approximately 32–36 % for both types of housing, which is significantly higher than found in other studies that considered these two types of housing (Fjeldaas et al. 2007; Becker et al. 2014b; Jury et al. 2021). In Norway, cows in loose housing systems had higher prevalences of HHE, SH, SU, WLD and DD than cows in tie stalls (Sogstad et al. 2005; Fjeldaas et al. 2007), while a mean lameness prevalence of 21 % was reported in cows in Canada kept in loose housing in herds of comparable sizes to those in Austria compared with 15 % in tie stalls; the report does not mention the underlying claw lesions (Jewell et al. 2019).

Logistic regression analysis also found a significant effect of breed on the incidence and type of individual claw lesions at the individual animal level. Brown Swiss cows had the lowest incidence of all claw lesions at 72.1 %, while Fleckvieh and Holstein Friesian cows had significantly higher incidences of ≥87.4 %. Fleckvieh cows showed the highest incidences of WLD and SH and Holstein Friesian cattle of DD and 'alarm' lesions. The findings are consistent with other reports that Brown Swiss cows had significantly lower prevalences of claw lesions and lameness than Fleckvieh and Holstein Friesian cows (Becker et al. 2014a,b; Jury et al. 2021; Kofler et al. 2021). However, our results must be interpreted with caution as Fleckvieh cows were far more prevalent, accounting for over 62 % of the total cow population, than Holstein Friesian cows at 28 % and Brown Swiss cows at slightly over 6 %. In addition to the well-known dependence on breed of the susceptibility to certain claw lesions, there are also genetical predispositions to various claw lesions (Van der Spek et al. 2013; Heringstad et al. 2018; Biemans et al. 2019). These make data sets from as large a proportion of the national cattle population as possible important for the long-term genetic improvement of claw health in dairy cows (Onyiro et al. 2008; Van der Linde et al. 2010; Ødegård et al. 2013; Heringstad et al. 2018; Biemans et al. 2019).

Our interpretation of the evaluation of claw health data over ten years comes with some caveats. First, there was an irregular distribution of data sets between individual farms and within the same farms over the ten years, with significantly fewer data sets especially from the earlier years, largely because the electronic documentation of claw health data was only established in Austria from 2009 (Kofler et al. 2011). Furthermore, some farms and test years presented data from one to three herd trimmings, where more than 50 % of the mean number of cows per farm were trimmed, whereas other farms had four or more trimming visits in a single year on which at most only a small number of cows were treated. By including data from all herd trimmings and data from only few, mostly lame, animals over this ten-year period, we have accurately depicted the overall claw health on the farms in the four federal provinces we studied. This conclusion is supported by a methodologically similar analysis of claw health data from 2020 that found comparable incidences of many claw lesions (Kofler et al. 2022). A Canadian study of herd trimmings (≥90 % of cattle per farm were trimmed but data from therapeutic hoof trimmings were not included) from 355 herds over four years (Arango-Sabogal et al. 2020) and a Swiss study of data from only a single herd trimming visit (≥80 % of cattle per farm had been trimmed) report significantly lower mean incidences/prevalences of claw lesions (Jury et al. 2021). The discrepancy might stem from improved animal management and housing conditions, as well as from the possibility that the assessments did not consider claw lesions treated individually due to lameness events (therapeutic hoof trimming) outside the regular herd trimmings (Arango-Sabogal et al. 2020; Jury et al. 2021).

The way data are documented also influences their accuracy. For example, it is important to know whether a study recorded three levels of severity for each claw lesion, as we did, or not, as in the Canadian study (Arango-Sabogal et al. 2020) and in an evaluation of Austrian dairy herds in 2020 (Kofler et al. 2022). The variation in documentation could contribute to the differences in observed incidences (ICAR 2022). In addition, our results are probably not representative of the entire Austrian dairy population as the vast majority of data came from four of the nine federal provinces. However, as these provinces contain the most and the largest dairy farms in Austria (Rinderzucht AUSTRIA 2022), the results can still be considered relevant.

The collection of claw health data from a significant portion of a country's dairy cattle requires a substantial team of coordinated hoof trimmers. To ensure high-quality results, the data have to be centralized, analysed and optimised for use (Kujala et al. 2009; Sandgren et al. 2009; Charfeddine & Pérez-Cabal 2017; Thomsen et al. 2019). It is important not to overlook the possibility that the hoof trimmers could themselves be a source of variation and thus diminish data quality. All hoof trimmers involved in the 'KQW' project had completed a hoof-trimming course and had participated in an interobserver reliability test to check the degree of agreement of the diagnosis of claw lesions against a gold standard. Our data analysis was restricted to records from the 31 hoof trimmers for whom the weighted Cohens Kappa value was ≥0.61, indicating substantial to almost perfect agreement (Landis & Koch 1977). Furthermore, we considered all three severity scores of claw lesions, including score 1 (Kofler et al. 2023). Interobserver reliability tests were also performed for a similar project on claw health in Switzerland, which also set a weighted Cohens-Kappa value of >0.6 as a minimum requirement for data use (Jury et al. 2021). Thus, the data are suitable for defining key parameters and thresholds for claw health in dairy herds (Huber et al. 2021; Kofler et al. 2022) and are indispensable for computing herd prevalences/incidences for scientific studies (Charfeddine & Pérez-Cabal 2017; Arango-Sabogal et al. 2020; Jury et al. 2021). Likewise, as an absolute prerequisite for computing key claw health measurements, only data sets validated according to published guidelines should be included (ICAR 2022). This criterion was applied in the present and in former studies for benchmarking claw health in dairy cows (Huber et al. 2021; Jury et al. 2021; Kofler et al. 2022). Documentation of claw health data can also be used by veterinarians to monitor the progression of claw health over time as part of dairy herd health management and to monitor the effect of on-farm measures for improvement (DeFrain et al. 2013; Thomsen et al. 2019; Arango-Sabogal et al. 2020; Garvey 2022).

Conclusions for practice

We make the following recommendations to reduce the incidences of claw lesions in dairy herds, especially 'alarm' lesions:

1. The electronic documentation of claw lesions during every hoof-trimming visit has significant benefits. The practice should become standard procedure for visits by professional hoof trimmers to enable the continuous monitoring of claw health.
2. Data analysis and interpretation: it is important that the professional hoof trimmer and the farm veterinarian analyse claw health data together after each trimming visit. The procedure should be integrated into overall herd health management.
3. Reduction or avoidance of 'alarm' lesions: the focus of prevention and treatment should be on these claw lesions, which are always painful and severely affect animal welfare, even if they have a lower incidence than other claw lesions.
4. Regular preventive hoof-trimming, ideally every four (to six) months, based on individual farm conditions and breed of dairy cows, is essential. This approach prevents problems rather than merely addressing lameness when it occurs. Cows in higher

lactation numbers are at a higher risk of CHDL and should therefore be trimmed at intervals of approximately four months.
5. Adjusting hoof-trimming timing to coincide with dry-off and the early lactation period (around 40 to 60 DIM) can significantly benefit claw health. This is especially crucial for lame cows during these vulnerable phases, considering both animal welfare and the significant economic implications related to milk yield, fertility and culling rates.

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Fazit für die Praxis:
Basierend auf den Ergebnissen dieser Studie werden folgende Maßnahmen zur Verringerung von Klauenläsionen in Milchrindherden empfohlen: 1. Elektronische Dokumentation von Klauenläsionen bei jeder Klauenpflege; 2. Bewertung der Ergebnisse durch Klauenpfleger und Betreuungstierarzt nach jeder Klauenpflege; 3. Verringerung/Vermeidung von Alarmläsionen, die immer schmerzhaft und das Tierwohl beeinträchtigen; 4. Regelmäßige (alle 4–6 Monate) Klauenpflege, um Lahmheiten vorzubeugen. Insbesondere bei Kühen mit höherer Laktationszahl, welche dadurch ein höheres Risiko aufweisen an CHDL zu erkranken, wird eine Klauenpflege alle 4 Monate empfohlen; 5. Abstimmung der Klauenpflegezeitpunkte mit dem Trockenstellen der Kühe und der Frühlaktation (40.–60. Tag der Laktation). Das ist besonders für lahme Kühe während dieser Risikoperioden wichtig, vor allem aus Tierschutzerwägungen aber auch aus wirtschaftlichen Gründen.

Conflict of interest
The authors declare no conflict of interest.

References

Arango-Sabogal JC, Desrochers A, Lacroix R, Christen AM, Dufour S. Prevalence of foot lesions in Québec dairy herds from 2015 to 2018. J Dairy Sci. 2020;103(12):11659–11675. DOI:10.3168/jds.2020-18191

Barker ZE, Amory JR, Wright JL, Mason SA, Blowey RW, Green LE. Risk factors for increased rates of sole ulcers, white line disease, and digital dermatitis in dairy cattle from twenty-seven farms in England and Wales. J Dairy Sci. 2009;92(5):1971–1978. DOI:10.3168/jds.2008-1590

Becker J, Steiner A, Kohler S, Koller-Bähler A, Wüthrich M, Reist M. Lameness and foot lesions in Swiss dairy cows: II. Risk factors. Schweiz Arch Tierheilkd. 2014(a);156(2):79–89. DOI:10.1024/0036-7281/a000554

Becker J, Steiner A, Kohler S, Koller-Bähler A, Wüthrich M, Reist M. Lahmheit und Klauenerkrankungen bei Schweizer Milchkühen: I. Häufigkeit. Schweiz Arch Tierheilkd. 2014(b);156(2):71–78. DOI:10.1024/0036-7281/a000553

Bergsten C, Blowey RD, Fiedler A, Geldof J, Holzhauer M, Kloosterman P, et al. Five-point plan for control of digital dermatitis. 2017 [cited 2024 Jan 14]. Available from: https://www.delaval.com/globalassets/switzerland/broschuren/deutsch/der-5-punkte-plan-zur-kontrolle-der-dermatitis-digitalis.pdf

Biemans F, De Jong MCM, Bijma P. Genetic parameters and genomic breeding values for digital dermatitis in Holstein Friesian dairy cattle: host susceptibility, infectivity and the basic reproduction ratio. Genet Sel Evol. 2019;51:67. DOI:10.1186/s12711-019-0505-3

Bruijnis MR, Beerda B, Hogeveen H, Stassen EN. Assessing the welfare impact of foot disorders in dairy cattle by a modeling approach. Animal. 2012;6(6):962–970. DOI:10.1017/S1751731111002606

Charfeddine N, Pérez-Cabal MA. Effect of claw disorders on milk production, fertility, and longevity and their eco-nomic impact in Spanish Holstein cows. J Dairy Sci. 2017;100(1):653–665. DOI:10.3168/jds.2016-11434

Cook NB, Strebe A, Karlen K. Prevalence and risk factors for corkscrew claw syndrome in dairy cattle. AABP Proceedings St. Louis (MO) 2019;52(2). p. 362. DOI:10.21423/aabppro20197249

DeFrain JM, Socha MT, Tomlinson DJ. Analysis of foot health records from 17 confinement dairies. J Dairy Sci. 2013;96(11):7329–7339. DOI:10.3168/jds.2012-6017

Ebert F, Černá A, Klötzer P, Wagner R, Schären M, Ullrich E, et al. Untersuchung und Bewertung der Haupteinflussfaktoren auf die Entstehung von infektiösen Klauenerkrankungen des Dermatitis

Digitalis–Komplexes. Leipziger Blaue Hefte. 2020: 10. Leipziger Tierärztekongress–Tagungsband 3: p. 311–313.

Egger-Danner C, Nielsen P, Fiedler A, Müller K, Fjeldaas T, Döpfer D, et al. 2015. ICAR Claw Health Atlas, Online-Publication ICAR, Rome [cited 2023 Jul 14]. Available from: http://www.icar.org/Documents/ICAR_Claw_Health_Atlas.pdf

Fjeldaas T, Nafstad O, Fredriksen B, Ringdal G, Sogstad AM. Claw and limb disorders in 12 Norwegian beef-cow herds. Acta Vet Scand. 2007;49(1):24. DOI:10.1186/1751-0147-49-24

Foditsch C, Oikonomou G, Machado VS, Bicalho ML, Ganda EK, Lima SF, et al. Lameness prevalence and risk factors in large dairy farms in upstate New York - Model development for the prediction of claw horn disruption lesions. PLoS One. 2016;11(1):e0146718. DOI:10.1371/journal.pone.0146718

Fuerst-Waltl B, Egger-Danner C, Guggenbichler S, Kofler J. Auswirkung von Lahmheit auf Fruchtbarkeitsmerkmale bei Fleckvieh-Kühen in Österreich – Ergebnisse aus dem Efficient-Cow-Projekt. Schweiz Arch Tierheilkd. 2021;163(11):721–736. DOI:10.17236/sat00323

Garvey M. Lameness in dairy cow herds: disease aetiology, prevention and management. Dairy. 2022;3(1):199–210. DOI:10.3390/dairy3010016

Greenough PR. Bovine laminitis and lameness - a hands on approach. Saunders Elsevier, Philadelphia, 2007; p. 8–198.

Griffiths BE, Grove White D, Oikonomou G. A cross-sectional study into the prevalence of dairy cattle lameness and associated herd-level risk factors in England and Wales. Front Vet Sci. 2018;5:65. DOI:10.3389/fvets.2018.00065

Gundelach Y, Schulz T, Feldmann M, Hoedemaker M. Effects of increased vigilance for locomotion disorders on lameness and production in dairy cows. Animals (Basel). 2013;3(3):951–961. DOI:10.3390/ani3030951

Heringstad B, Egger-Danner C, Pryce JE, Stock KF, Kofler J, Sogstad AM, et al. Invited review: Genetics and claw health: Opportunities to enhance claw health by genetic selection. J Dairy Sci. 2018;101(6):4801–4821. DOI:10.3168/jds.2017-13531

Huang Y-C, Shanks RD, McCoy GC. Evaluation of fixed factors affecting hoof health. Livestock Produc Sci 1995;44(2):115–124.

Huber S, Bernhard J, Syring C, Steiner A. Erarbeitung von Kennzahlen und Grenzwerten zur Klauengesundheit beim Schweizer Rindvieh. Schweiz Arch Tierheilkd. 2021;163(2):139–152; DOI:10.17236/sat00285

Hulek M, Sommerfeld-Stur I, Kofler J. Prevalence of digital dermatitis in first lactation cows assessed at breeding cattle auctions. Vet J. 2010;183(2):161–165. DOI:10.1016/j.tvjl.2008.11.001

ICAR. ICAR Guidelines: Section 7 - Functional traits in dairy cattle. 2022 [cited 2023 Jul 14]. Available from: https://www.icar.org/Guidelines/07-Bovine-Functional-Traits.pdf

Jewell MT, Cameron M, Spears J, McKenna SL, Cockram MS, Sanchez J, et al. Prevalence of lameness and associated risk factors on dairy farms in the Maritime Provinces of Canada. J Dairy Sci. 2019;102(4):3392–3405. DOI:10.3168/jds.2018-15349

Jury A, Syring C, Becker J, Locher I, Strauss, G, Ruiters M, Steiner A. Prävalenz von Klauenveränderungen in Schweizer Rindviehbetrieben. Schweiz Arch Tierheilkd. 2021;163(11):779–790. DOI:10.17236/sat00327

Kofler J, Hoefler M, Hartinger T, Castillo-Lopez E, Huber J, Tichy A, et al. Effects of high concentrate-induced subacute ruminal acidosis severity on claw health in first lactation Holstein cows. Animals. 2023;13(8):1418. DOI:10.3390/ani13081418

Kofler J, Altenbrunner-Martinek B. Qualitätssicherung bei der Behandlung von Klauen- und Zehenerkrankungen des Rindes – Vorstellung von Standardvorgehensweisen zur Erzielung besserer Therapieerfolge und zur Reduktion des Antibiotikaeinsatzes. Wien Tierarztl Monat – Vet Med Austria. 2022;109:Doc8. DOI:10.5680/wtm000008

Kofler J, Fiedler A, Charfeddine N, Capion N, Fjeldaas T, Cramer G, et al. ICAR Claw Health Atlas – Appendix 1 - Digital Dermatitis Stages (M-stages). ICAR Online-Publication 2020(a). [cited 2023 Jul 14]. Available from: https://www.icar.org/Documents/ICAR-Claw-Health-Atlas-Appendix-1-DD-stages-M-stages.pdf

Kofler J, Fiedler A, Charfeddine N, Capion N, Fjeldaas T, Cramer G, et al. ICAR Claw Health Atlas – Appendix 2 - Digital Dermatitis-associated Claw Horn Lesions. ICAR Online-Publikation 2020(b). [cited 2023 Jul 14]. Available from: https://www.icar.org/Documents/ICAR-Claw-Health-Atlas-Appendix-2-DD-associated-Claw-Horn-Lesions.pdf

Kofler J, Fuerst-Waltl B, Dourakas M, Steininger F, Egger-Danner C. Auswirkung von Lahmheit auf die Milchleistung bei Milchkühen in Österreich – Ergebnisse aus dem Efficient- Cow-Projekt. Schweiz Arch Tierheilkd. 2021;163(2):123–138. DOI:10.17236/sat00290

Kofler J, Hangl A, Pesenhofer R, Landl G. Evaluation of claw health in heifers in seven dairy farms using a digital claw trimming protocol and claw data analysis system. Berlin Munch Tierarztl Wochenschr 2011;124(7–8):272–281.

Kofler J, Pesenhofer R, Landl G, Sommerfeld-Stur I, Peham C. Langzeitkontrolle der Klauengesundheit von Milchkühen in 15 Herden mithilfe des Klauenmanagers und digitaler Kennzahlen. Tierarztl Prax Ausg G Grosstiere Nutztiere. 2013;41(G):31–44. DOI:10.1055/s-0038-1623146

Kofler J. Computerised claw trimming database programs as the basis for monitoring hoof health in dairy herds. Vet J. 2013;198 (2):358–361. DOI:10.1016/j.tvjl.2013.06.009

Kofler J., Suntinger M., Mayerhofer M., Linke K., Maurer L., Fiedler A., et al. Benchmarking based on regularly recorded claw health data of Austrian dairy cattle for implementation in the Cattle-Data-Network (RDV). Animals. 2022;12:808. DOI:10.3390/ani12070808

Kujala M, Dohoo IR, Laakso M, Schnier C, Soveri T. Sole ulcers in Finnish dairy cattle. Prev Vet Med. 2009;89:227–236. DOI:10.1016/j.prevetmed.2009.02.007

Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;3(1):159–174.

Lemmens L, Schodl K, Fuerst-Waltl B, Schwarzenbacher H, Egger-Danner C, Linke K, et al.. The combined use of automated milking system and sensor data to improve detection of mild lameness in dairy cattle. Animals. 2023;13:1180. DOI:10.3390/ani13071180

LFI-Ländliches Fortbildunginstitut: Klauengesundheit im Griff – mit System und Voraussicht - Ein Leitfaden für die Praxis; Online publication, Ländliches Fortbildungsinstitut LFI (editor), 2021. [cited 2023 Nov 15]. Available from: https://www.lko.at/tiergesundheit-klauengesundheit-im-griff-mit-system-und-voraussicht+2400+3492182

Machado VS, Caixeta LS, McArt JA, Bicalho RC. The effect of claw horn disruption lesions and body condition score at dry-off on survivability, reproductive performance, and milk production in the subsequent lactation. J Dairy Sci. 2010;93(9):4071–4078. DOI:10.3168/jds.2010-3177

Manske T, Hultgren J, Bergsten C. The effect of claw trimming on the hoof health of Swedish dairy cattle. Prev Vet Med. 2002;54:113–129. DOI:10.1016/S0167-5877(02)00020-X

Murray RD, Downham DY, Clarkson MJ, Faull WB, Hughes JW, Manson FJ, et al. Epidemiology of lameness in dairy cattle: description and analysis of foot lesions. Vet Rec. 1996;138(24):586–591; DOI:10.1136/vr.138.24.586

Ødegård C, Svendsen M, Heringstad B. Genetic analyses of claw health in Norwegian Red cows. J Dairy Sci. 2013;96(11):7274–7283. DOI:10.3168/jds.2012-6509

Oehme B, Grund S, Munzel J, Mülling CKW. Kinetic effect of different ground conditions on the sole of the claws of standing and walking dairy cows. J Dairy Sci. 2019;102(11):10119–10128. DOI:10.3168/jds.2018-16183

Onyiro OM, Andrews LJ, Brotherstone S. Genetic parameters for digital dermatitis and correlations with locomotion, production, fertility traits, and longevity in Holstein-Friesian dairy cows. J Dairy Sci. 2008;91(10):4037–4046. DOI:10.3168/jds.2008-1190

Osová A, Hund A, Mudron P. Interdigital phlegmon (foot rot) in dairy cattle - an update. Wien Tierarztl Monat – Vet Med Austria. 2017;104:209–220.

R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. 2021. [cited 2023 Jul 14]. Available from: https://www.R-project.org/

Refaai W, Van Aert M, Abd El-Aal AM, Behery AE, Opsomer G. Infectious diseases causing lameness in cattle with a main emphasis on digital dermatitis (Mortellaro disease). Livestock Sci. 2013;156(1–3):53–63. DOI:10.1016/j.livsci.2013.06.004

Rinderzucht AUSTRIA 2022. ZuchtData-Jahresbericht 2022. Online publication. [cited 2023 Jul 14]. Available from: https://www.rinderzucht.at/downloads/jahresberichte.html

Sadiq MB, Ramanoon SZ, Mansor R, Syed-Hussain SS, Shaik Mossadeq WM. Claw trimming as a lameness management practice and the association with welfare and production in dairy cows. Animals (Basel). 2020;10(9):1515. DOI:10.3390/ani10091515

Sandgren CH, Lindberg A, Keelin LJ. Using a national dairy database to identify herds with poor welfare. Anim Welfare. 2009;18:523–532. DOI:10.1017/S0962728600000944

Sogstad AM, Fjeldaas T, Østerås O, Plym Forshell K. Prevalence of claw lesions in Norwegian dairy cattle housed in tie stalls and free stalls. Prev Vet Med. 2005;70(3–4):191–209. DOI:10.1016/j.prevetmed.2005.03.005

Solano L, Barkema HW, Pajor EA, Mason S, LeBlanc SJ, Zaffino Heyerhoff JC, et al. Prevalence of lameness and associated risk factors in Canadian Holstein-Friesian cows housed in freestall barns. J Dairy Sci 2015;98:6978–6991. DOI:10.3168/jds.2015-9652

Suntinger, M. Klauen-Q-Wohl – Klauenpflege dokumentieren. Fleckvieh Austria Magazin. 2019;6:6–7.

Tadich N, Flor E, Green L. Associations between hoof lesions and locomotion score in 1098 unsound dairy cows. Vet J. 2010;184:60–65. DOI:10.1016/j.tvjl.2009.01.005

Thomas HJ, Miguel-Pacheco GG, Bollard NJ, Archer SC, Bell NJ, Mason C, et al. Evaluation of treatments for claw horn lesions in dairy cows in a randomized controlled trial. J Dairy Sci. 2015;98:4477–4486. DOI:10.3168/jds.2014-8982

Thomsen PT, Foldager L, Raundal P, Capion N. Lower odds of sole ulcers in the following lactation in dairy cows that received claw trimming around drying off. Vet J. 2019;254:105408. DOI:10.1016/j.tvjl.2019.105408

Thomsen PT, Capion N, Foldager L. Higher odds of abortion in dairy cows hoof trimmed late in gestation. Res Vet Sci. 2020;133:1–3. DOI:10.1016/j.rvsc.2020.08.016

Van Amstel SR. Corkscrew Claw. Vet Clin North Am Food Anim Pract. 2017;33(2):351–364. DOI:10.1016/j.cvfa.2017.02.010

Van der Linde C, De Jong G, Koenen EPC, Eding H. Claw health index for Dutch dairy cattle based on claw trimming and conformation data. J Dairy Sci. 2010;93(10):4883–4891. DOI:10.3168/jds.2010-3183

Van der Spek D, Van Arendonk JAM, Vallée AAA, Bovenhuis H. Genetic parameters for claw disorders and the effect of preselecting cows for trimming. J Dairy Sci. 2013;96(9):6070–6078. DOI:10.3168/jds.2013-6833

Van der Tol P, Metz J, Noordhuizen-Stassen EN, Back W, Braam CR, Weijs WA. The pressure distribution under the bovine claw during square standing on a flat substrate. J Dairy Sci. 2002;85(6):1476–1481. DOI:10.3168/jds.S0022-0302(02)74216-1

Von Keyserlingk MAG, Barrientos A, Ito K, Galo E, Weary DM. Benchmarking cow comfort on North American freestall dairies: lameness, leg injuries, lying time, facility design, and management for high-producing Holstein dairy cows. J Dairy Sci. 2012;95(12):7399–7408. DOI:10.3168/jds.2012-5807

Wenz JR, Giebel SK. Retrospective evaluation of health event data recording on 50 dairies using Dairy Comp 305. J Dairy Sci. 2012;95:4699–4706. DOI:10.3168/jds.2011-5312

ZAR. Klauen-Q-Wohl - 2017. [cited 2024 Jan 14]. Available from: https://www.rinderzucht.at/projekt/klauen-q-wohl.html

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