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Longitudinal study of udder cleft dermatitis in 5 Dutch dairy cattle herds

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ABSTRACT

Udder cleft dermatitis (UCD) is a skin lesion in dairy cows, most often located between anterior parts of the udder and abdomen, but also found between the front quarters. A few recent studies have investigated the prevalence of UCD, but relatively little is known about its pathogenesis, clinical course, and duration. Therefore, the aim of this study was to investigate the incidence and recovery of UCD on high-prevalence herds. Five Dutch dairy herds with a UCD prevalence of at least 6% were visited weekly for 19 wk, followed by visits every other week for 26 wk. During each visit, all dry and lactating cows were inspected for the presence of UCD signs. If a UCD case was detected, the affected skin was photographed and the photo was subsequently examined by a research assistant. Cows were then classified according to the appearance of the skin into 3 categories: healthy (no photo: no signs), mild (photo: affected skin but no wound), or severe (photo: open wound). The overall mean within-herd prevalence of UCD was 38% and the overall mean incidence was 1.94 UCD episodes per 100 cow-weeks at risk. Incidence of UCD was significantly higher in cows in third or higher parity and significantly increased with DIM. Median observed duration of UCD was 16 wk. The UCD recovery was 3 times more likely for mild than for severe lesions. The probability of moving from one category to another between 2 consecutive visits was very low, indicating that rapid changes in appearance did not occur. The observed incidence of UCD was rather low, and the relatively high prevalence in the selected herds was most likely due to the long duration of lesions rather than a high incidence of new UCD cases.

Key words: udder cleft dermatitis, incidence, longitudinal study, dairy cow

INTRODUCTION

In recent years, severe skin lesions around the anterior parts of the udder of dairy cows have been reported. The lesions, known as udder cleft dermatitis, **UCD** (Beattie and Taylor, 2000; Warnick et al., 2002; Olde Riekerink et al., 2014; Persson Waller et al., 2014), are mainly located between anterior parts of the udder and abdomen, but also found between the 2 front quarters. The lesions may vary in (clinical) appearance and size, but are usually characterized by a variety of the following signs: erythema, sebum, transudate, crusts, and thickened skin. In more severe cases, signs of necrosis of the skin and open wounds can be found, but signs of general disease are hardly seen (Persson Waller et al., 2014). In the worst cases, UCD can result in death caused by laceration of the mammary vein.

Reports of UCD cases are scarce, and not much is known about its etiology, clinical course, or duration. A few studies on UCD provide data on the prevalence of UCD in a specific problem herd (Beattie and Taylor, 2000; Warnick et al., 2002; Evans et al., 2010). More recently, studies have been carried out on randomly selected herds that included multiple herds (Olde Riekerink et al., 2014; Persson Waller et al., 2014). The prevalence in these latter studies varied from 0 to 39% affected cows per herd at any particular moment. Several risk factors, such as milk production level and the occurrence of mastitis or digital dermatitis, have been suggested to be associated with UCD (Boyer and Singleton, 1998; Stamm et al., 2009; Persson Waller et al., 2014), but a causal mechanism has not yet been identified.

Cross-sectional prevalence studies provide a snapshot of the situation at one time point but do not take into account the course of the condition in individual cows or within the herd. Therefore, the aims of this longitudinal study were to determine the incidence and duration of UCD in high-prevalence Dutch dairy herds and to identify possible cow-level risk factors.

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MATERIALS AND METHODS

A longitudinal study was performed from January 23 to December 9, 2013, on 5 Dutch dairy farms in the middle of the Netherlands. Farms were visited weekly or every other week, and during every herd visit all cows present were inspected for signs of UCD.

Selection of Herds

Five dairy herds were selected from the University Large Animal Practice (**ULP**) at Harmelen, the Netherlands, to participate. The housing system was comparable, and cows were housed in freestalls with concrete slatted floors. One herd used an automatic milking system, and the other 4 used a herringbone parlor. Bedding material in the boxes varied (Table 1). Study size was limited by expected weekly cow inspection on a fixed day every week and by financial restraints. The main criterion on which herds were selected was a UCD prevalence of at least 6%, to ensure sufficient cases. Other herd inclusion criteria were a milk production level of >7,500 kg of milk/cow-year, participation in a milk recording system every 4 to 6 wk, and a herd size of approximately 60 to 100 cows. The latter criterion was chosen for practical reasons, as all cows present had to be inspected every herd visit. In addition, this reflected the 2013 average Dutch herd size of 82 cows. Veterinarians from ULP provided information to identify herds with cows suffering from UCD. Of the 335 farms serviced by ULP veterinarians, 12 herds were identified for potential inclusion based on UCD information. Six herds did not meet the criteria because prevalence was too low and one farmer did not agree with the research protocol, with the remaining 5 herds included in the study.

Farmers consented to refrain from any treatment of UCD affected cows. This observational study was approved by the Ethical Committee of Utrecht University, and was not deemed an animal experiment under the Dutch Law.

Collection of Data

Herds were visited weekly between January 23 and June 7, 2013, on a fixed weekday, and every 2 wk from then on until December 9, 2013. Visit frequency was decreased because neither clinical appearance nor occurrence of cases changed rapidly. During the final 2 visits of the study period, only UCD-affected animals were followed up for potential recovery; no new cases were included.

On the day of the visit, following morning milking, all lactating and dry cows were fixed into headlocks and visually inspected one by one. Inspection of the animals was always carried out by the same research technician, whereas assistance could vary during the visits. The research technician used a lamp and hand mirror in one hand and spread the front quarters of the udder with the other hand for proper inspection of the skin between the 2 front quarters and skin of the anterior junction between the udder and the abdominal wall. Signs indicative for UCD were presence of crusts, transudate, sebum, erythema, granulation tissue, scar tissue, or an open wound. If a UCD case was observed, front quarters were spread by hand by one person and the research technician made a ventral photo of the lesions using a stick to which a mirror and camera were attached. Photos of the UCD lesions were taken via the mirror. Cow identification cards were clipped on a folding ruler and were photographed together with the lesion. When no signs indicative for UCD were observed, the udder of the cow was not photographed and therefore the cow was not recorded.

Interpretation of Photos

Initially, photos were evaluated using the scoring system by Olde Riekerink et al., (2014), in which individual signs were scored and the scores combined. However, when we checked the repeatability of this scoring system by submitting 15 photos to be examined by 5 ULP veterinarians, we found that their scores varied consid-

Table 1. Characteristics of the 5 Dutch dairy herds included in the longitudinal udder cleft dermatitis (UCD) study and number of UCD episodes observed per herd

Herd	Herd size (no. of cows)	305-d milk production (kg)	Bedding material in cubicle	Type of milking parlor	Pasturing in summer	UCD episodes,[1] n = 289
1	56	9,151	None	2 × 5 parallel herringbone	Yes	45
2	79	9,163	Straw	2 × 6 herringbone	No	59
3	66	10,378	Sawdust	2 × 5 herringbone	Yes	50
4	89	8,648	Sawdust	2 × 6 herringbone	Yes	66
5	91	9,252	Straw	Automatic milking system	No	69

[1]UCD episode = at least 2 consecutive UCD observations regardless of the visiting interval.

erably. The consistency of this scoring system was low (data not shown), probably due to the fact that not all of the observed combinations of signs fit into the proposed scoring system. Thus, combining characteristics into one score was deemed infeasible and we instead decided to record single aspects of the affected skin one by one with no predefined overall classification. Six characteristics indicative for UCD and the location of the lesions were scored (Appendix Table A1). Two trained student assistants scored all photos according to this system. One student scored the photos from January through June, and the other from July until December. The second student was intensively trained by the first one, to ensure uniformity. Evaluation of all individual characteristics did not point to obvious patterns in the observed characteristics. However, skin integrity was the most distinctive characteristic, allowing a division of UCD cases into 2 categories: mild UCD, in which the skin showed some characteristics of UCD but was intact (no open wound), and severe UCD, in which an open wound was present.

Definitions of UCD Prevalence and UCD Incidence

In our paper, an observation means a cow was inspected during the herd visit. A UCD observation means a photo of the cow was taken, based on the presence of signs indicative of UCD. All nonphotographed cows received a healthy observation. Photos of UCD observations were classified as mild or severe based on the absence or presence of an open wound.

A UCD episode was defined based on at least 2 consecutive UCD observations, regardless of the interval (1 or 2 wk). A new UCD episode was preceded by at least 2 consecutive healthy observations. A series was defined as several consecutive mild or severe UCD observations (Appendix Figure A1). As the animals were followed over time, UCD episodes could change from mild into severe and vice versa; animals could recover from UCD and could become affected again during the study period. A cow could thus suffer multiple UCD episodes within the study period and UCD episodes could consist of one or more series. For example, a UCD episode could consist of a series of mild observations, followed by a series of severe observations, and followed again by mild observations, with no healthy observations in between.

Recovery was defined as a UCD episode followed by at least 2 consecutive healthy observations. The start or end of a UCD episode was not observed for all cows; some cows entered the study period with signs of UCD, others remained affected at the end of the study period, and yet others were affected during the full study period.

Data Recording

As only UCD-affected cows were photographed, test-day records were used to identify the number of examined cows to calculate prevalence (photographed animals as a percentage of herd). Parity, DIM, and the Dutch measure for individual standardized milk production level per animal were taken from the test-day records (www.CRV.nl; de Roos et al., 2004). Standardized milk production [Individuele Standaard Koe in Dutch (**ISK**)] allowed comparison of individual animals between herds, as all cows are corrected toward same parity, calving season, and DIM. The ISK is routinely reported for cows between 5 and 305 DIM, and represents the amount of kilograms milk on that day as if this cow was a second-parity cow that had calved in February or March and was 50 d in lactation.

In 3 of 5 herds, farmers could provide information on udder conformation traits as scored by the Dutch breeding organization during the first lactation of the animals (CRV, 2014). We analyzed 7 udder characteristics for potential association with UCD: fore udder attachment, fore and rear teat placement, fore teat length, udder depth, rear udder height, and udder cleft. All characteristics were originally scored from 1 to 9, but for the UCD analysis recoded in 3 classes (1–3, 4–6, and 7–9).

Statistical Analyses

Prevalence of UCD. The UCD prevalence was calculated per herd visit as the number of UCD observations over the total number of animals examined. The mean within-herd prevalence was based on all herd visits per herd, excluding the final 2 visits. An overall mean within-herd prevalence was calculated over all 5 herds.

Incidence of UCD. Udder cleft dermatitis incidence was calculated per herd visit as all new UCD episodes divided by all cows at risk during the previous herd visit multiplied by the weeks between herd visits, and standardized per 100 cow-weeks at risk. All cows with a healthy observation in the previous herd visit were considered to be at risk. The mean herd incidence was based on all herd visits per herd, excluding the final 2 visits. As the mean herd incidence did not differ significantly between herds, we calculated an overall mean incidence for the whole observation period over all 5 herds.

Appearance Before Transition. To investigate whether a mild UCD observation that changed into a severe UCD observation at the next visit had a different appearance just before transition than any mild observation, we compared mild observations with each

other as follows. For each mild observation followed by a severe observation, a random mild observation was selected (case-referent design). A Chi-square test was used to determine whether each scored characteristic (coverage, erythema, granulation tissue, or scar tissue) differed between these 2 groups of mild observations.

Regression Models. To study incidence and recovery rate, we analyzed the data using survival analysis. In the incidence model, the event was the start of a new UCD episode and in the recovery model the event was the end of a UCD episode. Both models contained right-censored data, because the total length of the healthy period was not always observed (incidence model) and similarly the total length of a UCD episode was not always observed (recovery model). Data were analyzed using Cox proportional hazard models with weekly time steps, with herd as a block factor, animal as random effect, and visiting interval as a factor. To study relative milk production as a possible cow-level risk factor, ISK was included as a time-varying covariate in the incidence model, as a continuous variable, and at 3 levels. The cut-off for the 3 levels were 1/3 and 2/3 percentile, at 39.3 and 45.6 kg of milk, respectively. To understand DIM and parity as possible cow-level risk factors, we fitted another incidence model with DIM as a time-varying covariate with parity as a factor. The start of the dry period was unknown from the test-day records. We therefore coded the variable DIM including the dry period until calving. The recovery model only included UCD episodes with UCD category (mild or severe) coded as a time-varying covariate. A mild series that changed to a severe series within a UCD episode was considered censored, and vice versa. The number of time-varying UCD episodes included in the model precluded estimation of possible risk factors such as ISK, parity, or DIM.

Logistic regression modeling was used to study the possible association between udder conformation traits and UCD, where UCD (yes/no) per cow was the dependent variable. This model included herd as a block factor and each udder conformation trait as a 3-level factor.

All models were developed with backward procedure and the best model was based on lowest Akaike's information criterion value, with a minimal difference of 2 (Burnham and Anderson, 2002). All analyses were carried out using R (version 3.2.2; libraries survival and coxme for survival models, function glm for logistic model; www.R-project.org).

Table 2. Prevalence of udder cleft dermatitis (UCD; mean, minimum, and maximum) per herd and over all herds

	Within-herd prevalence (%)				
Herd[1]	Mean	Minimum	Maximum	SD	95% CI
1	43.0	33	51	4.7	41.2–44.8
2	31.8	22	41	4.2	30.2–33.4
3	40.5	31	51	6.3	38.1–42.9
4	36.7	26	46	5.1	34.8–38.7
5	37.8	25	43	4.9	36.0–39.7
Overall	38.0	22	51	6.3	36.9–39.0

[1]Number of herd visits differs due to logistical reasons; herds 1 and 2 were visited 28 times, herds 3 to 5 were visited 29 times.

RESULTS

Descriptive Data

The mean annual herd size was 76 cows and mean annual milk production was 9,318 kg of milk/cow-year (Table 1). The most common breed in the participating herds was Holstein-Friesian, with a proportion of more than 95% per herd.

All herds were visited 28 or 29 times. During these visits a total of 457 individual cows were inspected and over 4,000 photos were taken. In the study period, 239 cows showed signs of UCD representing 289 UCD episodes, with a variation of 45 to 69 episodes per herd. Single episodes of UCD were present in 195 cows, 39 cows suffered twice from UCD, 4 animals had 3 episodes, and 1 animal had 4. Within these 289 UCD episodes, 311 series of consecutive mild observations were identified as well as 218 series of severe observations.

Prevalence of UCD

Prevalence of UCD was calculated per herd for each herd visit and ranged between 22 and 51% over all herd visits (Table 2). Mean within-herd prevalence over the whole study period varied between 31.8 and 43%, with an overall mean within-herd prevalence of 38% (95% CI: 36.9–39.0). In 3 out of 5 herds, severe observations were more frequent than mild observations (Figure 1).

Incidence of UCD and Risk Factors

Incidence of UCD per 100 cow-weeks at risk was calculated per herd visit and ranged between 0 and 9.3 (Table 3). Mean herd incidence varied between 1.83 and 2.05 per 100 cows-weeks at risk and the overall mean incidence calculated over all herds was 1.94 (95% CI: 1.57–2.31) per 100 cow-weeks at risk.

Results from the incidence model showed no significant incidence difference between herds, but herd was always kept in the model to correct for the clustering of animals within herds. Visiting frequency influenced

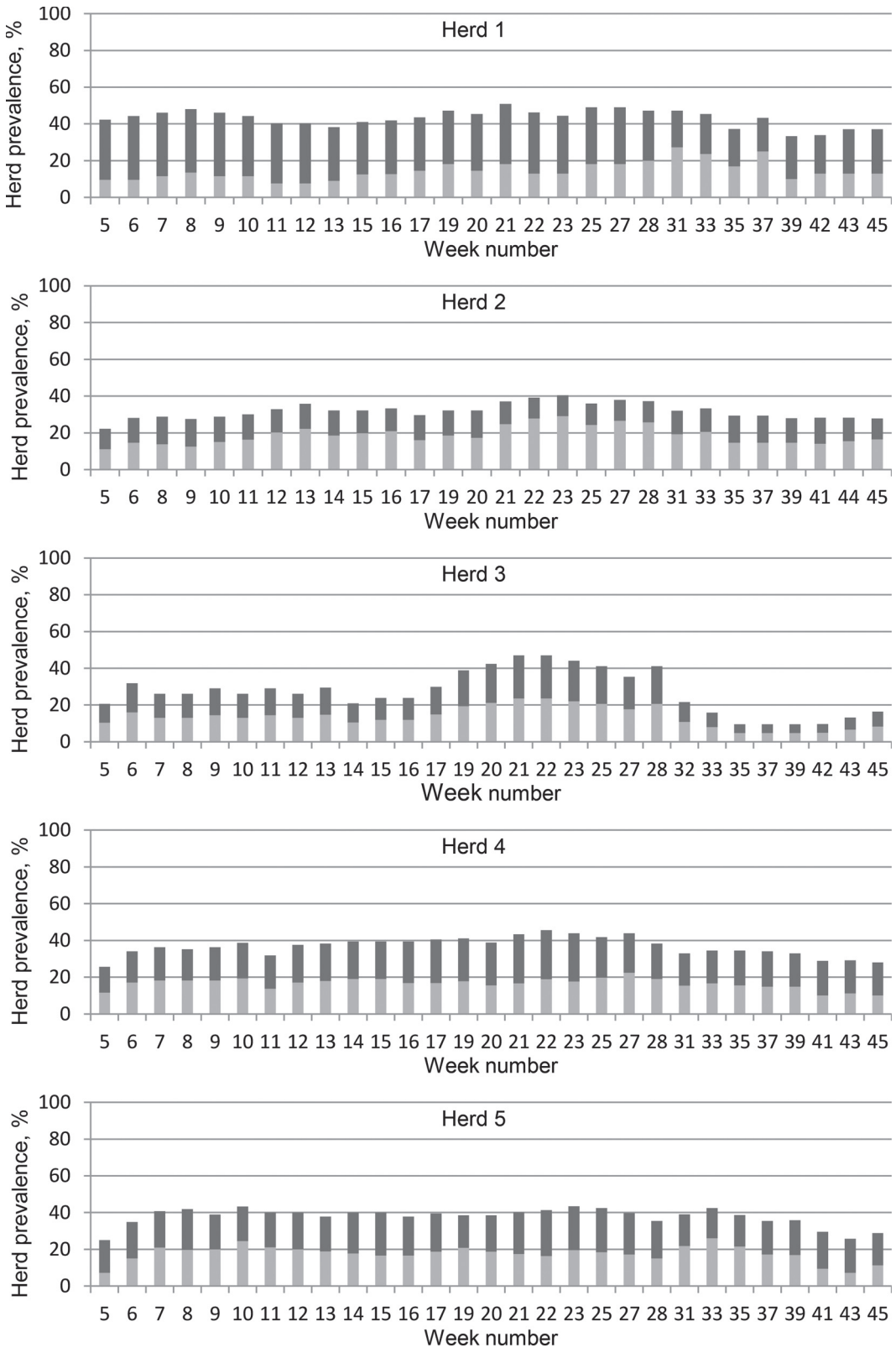

Figure 1. Prevalence of udder cleft dermatitis (UCD) observations per herd visit for 5 Dutch dairy herds, visited weekly at first and then every other week in 2014. Light gray indicates mild UCD observations, dark gray indicates severe UCD observations, and the x-axis indicates week number of herd visit.

weekly incidence rate and was also kept in the models. Using ISK as continuous variable did not improve the model, but ISK as a 3-level variable did improve model fit based on Akaike's information criterion. The ISK levels medium and high showed approximately 1.1 higher incidence rate compared with the lowest ISK level, but the 3 ISK levels did not differ significantly among each other. Results from the incidence model with parity and DIM revealed significant association between incidence and parity. Incidence was twice as high for cows in third or higher parity than for those in first parity [hazard ratio = 2.14 (95% CI: 1.25–3.67)], whereas the incidence increased slightly with an increasing DIM [hazard ratio = 1.002 (95% CI: 1.001–1.004)].

The 3 herds with udder conformation trait data totaled 340 cows. Of these, 97 (29%) showed signs of UCD during the study period. Using logistic regression analysis, no udder conformation trait showed any significant association with UCD.

Transitions Between UCD and Healthy Observations

Transitions from UCD (mild or severe) to healthy and vice versa were calculated between consecutive visits. Individual cows seemed to remain either healthy or UCD affected in subsequent observations rather than switch between healthy and UCD affected. The probability of moving from healthy to UCD affected between 2 consecutive visits was 3.65% of 6,488 healthy observations, and moving from UCD to healthy had a probability of 5.53% of 4,209 UCD observations (Appendix Table A2).

Appearance of Mild UCD Before Transition to Severe UCD

In total, 112 mild UCD observations followed by severe UCD observations showed more often crusts or transudate than the random selected mild cases (Chi-squared, $P < 0.05$). No difference in the other scored characteristics of UCD was observed between the 2 groups of mild observations.

Duration and Recovery of UCD Episodes

The median observed duration of all 289 UCD episodes (whether mild or severe) was 16 wk (range = 1–46 wk; mean = 20.7 wk). Within these episodes, the median duration of the 311 observed mild series was 5 wk (range = 1–45 wk; mean = 8.8 wk) and for the 218 observed severe series was 10 wk (range = 1–46 wk; mean = 16.2 wk). During the study period, 175 UCD episodes recovered. Results from the recovery model indicated that recovery rates did not differ significantly between herds. The weekly recovery rate for mild series was 3 times higher than for severe series [hazard ratio = 2.8 (95% CI: 1.96–4.00)].

Table 3. Incidence of new udder cleft dermatitis (UCD) episodes per 100 cow-weeks at risk in 5 Dutch dairy herds, given per herd and over all herds

	Incidence[2]			
Herd[1]	Mean	Minimum	Maximum	95% CI[2]
1	1.83	0	6.9	1.02–2.64
2	2.01	0	7.3	1.19–2.83
3	1.85	0	8.8	0.90–2.80
4	1.96	0	9.3	1.07–2.84
5	2.05	0	8.9	1.14–2.97
Overall	1.94	0	9.3	1.57–2.31

[1]Number of herd visits differed due to logistical reasons. Herds 1 and 2 were visited 26 times, and herds 3 to 5 were visited 27 times.

[2]The incidence is calculated as the number of new UCD episodes per herd visit divided by all cows at risk at the previous herd visit multiplied by weeks between herd visits, and standardized per 100 cow-weeks at risk.

DISCUSSION

The mean within-herd prevalence of UCD showed little variation between herds, but for all herds was much higher than anticipated by the farmers. At the start of the study, farmers expected a within-herd prevalence between 10 and 15%. Farmers may detect mild signs of UCD less often due to its anatomical position and the lack of general signs of disease. The overall mean within-herd prevalence of 38% was much higher than has been reported in previous studies because those studies were carried out on randomly selected herds (Olde Riekerink et al., 2014; Persson Waller et al., 2014), whereas our study was performed in high-prevalence herds. The overall mean incidence of UCD on the 5 herds was estimated at 1.94 per 100 cow-weeks at risk, with little variation between herds, and median observed duration of UCD episodes was 16 wk. The relatively high prevalence on the 5 farms, therefore, seems to be more a result of long duration rather than a high incidence. Recovery analysis showed that mild UCD episodes recovered at a higher rate than severe UCD episodes, reflecting the fact that the healing of open wounds is a lengthy process.

We found an association between parity and the presence of UCD: higher-parity cows had an increased risk of UCD than did first-parity cows, as has also been demonstrated in previous studies (Beattie and Taylor, 2000; Warnick et al., 2002; Persson Waller et al., 2014).

We hypothesized that the risk factor of higher parity might be associated with the anatomy and depth of the udder.

High milk production has also been suggested as a risk factor at cow level (Persson Waller et al., 2014) and at herd level (Olde Riekerink et al., 2014; Persson Waller et al., 2014). The herds in our study all had a production level varying between 8,648 and 10,378 kg of milk/cow-year, which is considered high compared with the average Dutch level of 8,200 kg of milk/cow-year. We therefore could not determine whether high production level was associated with herd-level occurrence of UCD. We did analyze a possible association for the standardized production (ISK) to evaluate whether relatively high-producing cows within high-producing herds were at higher risk for developing UCD. This variable showed a weak association with UCD. The model with parity and DIM showed both higher parity and longer DIM to be positively associated with UCD incidence, warranting further study on the role of milk production capacity and the dry period in the etiology of UCD.

Following cows over time indicated that the progress of signs of UCD seems to be rather slow, given that cows tended to remain in the same category during 2 consecutive visits. The etiology of UCD is still unclear, although the presence of edema (Beattie and Taylor, 2000) or mange (Warnick et al., 2002) and the anatomy of the udder (Beattie and Taylor, 2000; Olde Riekerink et al., 2014; Persson Waller et al., 2014) seem to be associated. We hypothesized that contact between skin folds might contribute to the initiation of skin lesions. In the current study, we found no relationship between udder conformation traits and UCD episodes in the 3 herds where information on udder conformation traits was available. Other studies have reported that a strong fore udder attachment may be associated with a lower prevalence of UCD (Olde Riekerink et al., 2014; Persson Waller et al., 2014). The udder conformation traits as used in our study were based on inspections by a breeding company, which performs this inspections in first-calf heifers. These scores will belong to the animal for the rest of her life, irrespective of how the actual udder form may change over the following years. This is in contrast to inspections performed by Olde Riekerink et al. (2014) and Persson Waller et al. (2014), which were carried out at the same time that signs of UCD were scored and reflect more accurately the state of the udder. We suggest that udder conformation should be scored in parallel to UCD observations, because conformation traits are likely to vary over time and with DIM.

Mild UCD observations that changed to severe over time seemed to differ slightly in appearance before this transition compared with randomly selected mild UCD observations. Before the transition to severe, more crust or transudate in the affected area was observed than was seen in randomly selected mild observations. These observations were, however, not quantified exactly, and prediction of when a mild UCD case might become a severe case needs more research. More knowledge about the etiology, the bacterial flora in the skin, or triggering factors for transition from healthy to mild or severe UCD stage might help farmers to prevent this occurrence.

It seems unlikely that the course of severe UCD observations in our study was affected by the fact that farmers did not treat their cows when the first signs of mild UCD appeared. First, no effective therapy is available; furthermore, the majority of the farmers do not seem to recognize UCD until it has become severe. The long duration of mild UCD might at least provide opportunities to treat animals and thus to prevent severe UCD, providing an effective therapy becomes available and the farmers adopt some protocol that allows them to notice mild cases more easily.

Although the phenomenon UCD was first described some time ago, a useful and objective method to describe a case of UCD was lacking. The Dutch scoring system introduced by Olde Riekerink et al. (2014) turned out to be unsuitable for the longitudinal study of UCD, as we found combinations of signs that did not fit. For example, many of our observations consisted of sebum with or without other signs, whereas the presence of sebum was not included at all in the scoring system of Olde Riekerink et al. (2014). Our simple classification in healthy (no skin lesions), mild (one or several possible UCD lesions, but no wound), and severe (a wound with or without possible UCD lesions), meanwhile, shows little difference from the classification that Persson Waller et al. (2014) used in their prevalence study; therefore, the results of both studies are easily compared. Notwithstanding, the need for an objective case definition and an objective scoring system remain essential to compare UCD prevalence and UCD incidence among different studies and countries.

CONCLUSIONS

The incidence of UCD on 5 Dutch dairy farms with a high prevalence of UCD was estimated to be 1.94 per 100 cow-weeks at risk, with little variation between herds. The risk for UCD in cows in their third or higher parity was twice as high as in first-calf heifers. Median

observed duration of all UCD cases, whether mild or severe, was 16 wk. Probability of recovery within our study period was 3 times higher for mild lesions than for severe lesions. Providing farmers with protocols to detect UCD signs in an early stage, combined with effective treatment, might decrease the number of severe UCD and, therefore, decrease its negative effect on animal welfare. The causative mechanism of UCD and potential preventive factors still need to be elucidated.

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APPENDIX

Table A1. Scoring system for udder cleft dermatitis observations[1]

Characteristic[1]	Possible score			
Skin coverage	Normal	Transudate	Sebum	Crust
Erythema	No	Yes		
Granulation tissue	No	Yes		
Scar tissue	No	Yes		
Length affected skin (cm)	NA	1–5	6–15	>15
Length open wound (cm)	NA	1–5	6–10	>10

[1]All 6 characteristics were scored separately. For each characteristic it was determined whether it was observed (i.e., present) or not. The characteristics were (1) type and aspect of the skin coverage (presence of transudate, sebum, or crust); (2) presence of erythema; (3) presence of granulation tissue; (4) presence of scar tissue; (5) length of affected skin; and (6) length of open wound. Locations were scored as midline anterior to fore udder, or midline between fore quarters, or anterior to left/right fore quarter, as well as all combinations of the previous 3 locations. NA = not applicable.

Table A2. Probability of transition between healthy observations and udder cleft dermatitis (UCD) observations in 2 consecutive visits on 5 Dutch dairy herds

Current observation	Next observation	Number of transitions	Probability (%)
Healthy	Healthy	6,251	96.35
Healthy	UCD	237	3.65
Total		6,488	100
UCD	UCD	3,976	94.46
UCD	Healthy	233	5.53
Total		4,209	100
Total transitions		10,697	

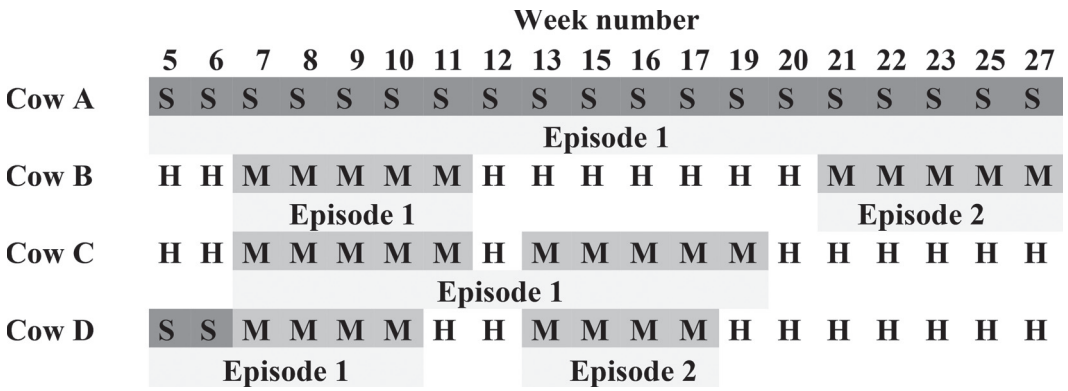

Figure A1. Schematic illustration of udder cleft dermatitis (UCD) observations, UCD episodes, and series. Observations are coded S (severe), M (mild), and H (healthy). Cow A had 1 UCD episode consisting of 1 series of severe observations, without observed start or end. Cow B had 1 new UCD episode consisting of 1 series of mild observations from which she recovered and a second new UCD episode consisting of 1 series of mild observations without observed end. Cow C had 1 new UCD episode consisting of one series of mild observations from which she recovered. Cow D had 1 UCD episode without observed start consisting of 1 series of severe and 1 series of mild observations from which she recovered and a second new UCD episode consisting of 1 series of mild observations from which she recovered.