

# **Survey and description of risk factors for *erosio ungulae* and *pododermatitis* *septica circumscripta* in Swiss dairy cows**



## **Research Project Veterinary Medicine University Utrecht**

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## 1. Abstract

Claw disorders are frequently reported in dairy cattle all over the world. The high prevalence of lameness due to claw disorders are stated as not acceptable and they give rise to a growing public concern about animal welfare. The dairy farm claw disorders erosio ungulae (EU) and pododermatitis septica circumscripta (PSC) were investigated on 21 dairy farms around Bern, Switzerland in the period between February and May 2013. The incidence rates were scored and compared to certain risk factors such as 'trimming frequency', 'achiever hoof trimming', 'method of trimming' and some risk factors regarding the housing system. Additional information derived from a questionnaire and was used to find other correlations such as 'cadastral zone', 'pasture in summer' and even the perception of the farmer. Further, the degree of lameness and the hygienic conditions of the cows were scored. Significant correlations between the claw disorders and certain risk factors could be used to achieve a better management for claw health. The prevalence of PSC on the dairy farms examined was that low that no conclusions could be drawn based on the results obtained for this claw disorder. Correlations between EU and the risk factors 'pasture', 'quality litter' and 'achiever hoof trimming' did not appear to be significant. Risk factors for which significance was found ( $P \leq 0.05$ ) with EU, are 'cadastral zone', 'breed', 'housing', 'bedding', 'manure', 'trimming frequency', 'biotin', 'perception', 'quantity litter' and 'method'. In conclusion, if the farmer's awareness concerning EU could be improved, proper actions could be taken to improve claw health and animal welfare, as discussed in this study.

## 2. Introduction

Claw disorders are frequently reported in dairy cattle all over the world. After infertility and mastitis, they are the third most common reason for involuntary culling (Enting et al., 1997). Diseases of the claw account for about 90% of all lameness incidents (Weaver, 2000). Claw disorders are distinguished at clinical and subclinical level and cause pain and discomfort at long term (Webster, 1995; Alban, 1995). This results in high economic losses. The high prevalence of lameness due to claw disorders are stated as not acceptable and they give rise to a growing public concern about animal welfare (Farm Animal Welfare Council, 1997). The aetiology of claw disorders is multifactorial (Greenough et al., 1997). Main influencing factors are breed, the formation of claw and horn (Alban, 1995), level of feeding, milk production (Green et al., 2002), housing systems and hygiene (Greenough et al., 1997; Vokey et al., 2001). The age and lactation stage (Alban, 1995) and claw trimming strategy (Manson and Leaver, 1998) are also risk factors. Despite previous studies, the risk factors for developing claw disorders are not completely identified. It is therefore of great importance to investigate the risk factors underlying specific claw disorders in more detail. In this case, the study is conducted on dairy farms around Bern, Switzerland, from February through June 2013.

### 2.1 Erosio ungulae

#### Description

Erosio ungulae (EU) is also called ‘heel horn erosion’ or ‘slurry heel’ (Figure 1). This claw disorder received international acknowledgement in 1976. Before this date, it was given a variety of common names, such as ‘stinky foot’ and ‘stable foot rot’. Very little literature is available about this claw disorder and it is often confused with under-running of the heel. Under-running of the heel is most frequently a complication of white line disease (Collick, 1997). EU is a decomposition of the ball horn, due to chemical and bacterial agents, with no affection of the adjacent hairy skin or the underlying dermis. It can occur as a primary disease in healthy claws or due to other diseases, such as laminitis, digital and interdigital dermatitis (Dirksen, 2002). The ball horn, or zone 6 (Figure 3), is more predisposed as other districts of the horn (Kempson et al., 1998). The prevalence of EU may increase in herds that have a high prevalence of interdigital dermatitis. This suggest a close relationship between these two claw disorders. In some cases, there is a lesion of the skin which may support the concept that interdigital dermatitis and EU have a common causal cause. Interdigital dematitis is strongly related to EU as a secondary complication.



Figure 1 Erosio ungulae

It has been found that at least 4% of a herd can be affected with erosion of the heel (Clarkson et al., 1993). Once in a while, infection will cause the soft horn of the heel to separate from the corium beneath. It starts between the cheeks of the heel bulbs, at that time, it causes little discomfort, but after a while, as more horn is destroyed, the longitudinal balance of the claw is disrupted. In young animals, it may appear as discrete craters which merge over time. It is usually more extensive the older the animal becomes. The lesions rapidly become darker in color and form a typically series of ridges. At the end, there is dark V-shaped erosion formed. The discolored horn is much softer than normal horn (Andersson and Lundström 1981; Collick, 1997; Lischer, 2000; Fiedler, 2003, Berntsen, 2002; Geyer and Abgottsporn 2002).

If weight-bearing is moved forward as a result of this process, the formation of a sole ulcer can be induced. Therefore, EU is one of the risk factors for a sole ulcer (Carvalho et al., 2005). In extreme instances, the build-up of heel horn can be so extreme that the pressure causes an inflammatory reaction to pressure in the corium of the heel. An alternative explanation is that pain caused by the hard edge of the skin/horn junction decreases wear of the heel horn which grows faster than it wears.

#### **Cause**

Although erosion ungulae was described over 30 years ago, little progress has been made in understanding the cause of it. In primary EU, especially environmental factors, such as hygiene and humidity are influencing the damage of the claw (Collick, 1997; Pijl, 2004). Moisture makes the claw horn swell and therefore, more vulnerable (Günther, 1991). Manure detaches the intracellular binding between horn cells. Urea destroyed the binding of intracellular keratin proteins (Mülling, 2002). This creates gaps in the horn. Predisposing seems to be excessive load on the ball area by high body weight (Dirksen, 2002) and sharply angled claws (Lischer, 2000).

Other authors place the EU as a secondary disease of the claw (Greenough and Vermunt 1991). Due to the damage around the vessel, horn is susceptible to environmental influences. *Dichelobacter (Bacteroides) nodosus* and other environmental pathogens such as *Fusobacterium* use the micro cracks in the horn as entry. The presence of *Dichelobacter (Bacteroides) nodosus* can be demonstrated with direct immunofluorescence in the germinal cell layers (Manske et al., 2002). This results in a compensatory proliferation of the horn anterior of the ball horn regions. This creates fissures in the horn, which in some cases can lead to painful damage of the corium (Collick, 1997).

The Dutchman Egbert Toussaint-Raven believed the condition to be encountered more commonly in animals affected with subclinical laminitis (Raven, 1989). In a tied housing system, EU is not a problem (Bergsten, 1995).

### Treatment

Even though there is a very high incidence of EU, only very few cases cause a significant degree of discomfort. On the other hand, it has been found routinely that Holsteins, with an average production of 9.800 kg of milk/year and with otherwise sound feet, increased their daily average milk production by 2 kilograms subsequent to the control of EU. If gross lesions are corrected during claw trimming, the effectiveness of foot bathing will be improved by allowing medicated solution to reach the otherwise sealed depth of the EU. Another negative effect of the interdigital dermatitis/heel horn erosion complex is that the horn production is stimulated, making it necessary for routine claw trimming to be performed more frequently (Enevoldsen et al., 1991).

If erosion is extensive, the weight-bearing zone of the heel/sole junction will move forward, causing traumatic reaction in the corium. This complication does cause the affected animal to become lame. The horn should be trimmed in such a manner that there is a slope towards the abaxial wall. Most hoof trimmers will spray the cut surface of the trimmed horn with a preparation containing copper sulfate or apply Stockholm tar. As digital dermatitis and interdigital dermatitis are often associated with EU, the primary disease must be treated to have a long-term improvement. Horn erosions will resolve provided that new lesions do not appear (Manske et al., 2002).

### Prevention

Routine claw trimming will prevent the development of advanced lesions. Regular foot bathing during the winter months reduces the severity of EU. Copper sulfate (5% solution) and formalin (1 - 5% solution) have been found to provide satisfactory results (Arkins et al., 1986).

## 2.2 Pododermatitis septica circumscripta

### Description

Pododermatitis septica circumscripta (PSC) is also called sole- or Rusterholz ulcer (Figure 2). PSC is a raw or granulating area, about 1 cm in diameter and typically located in zone 4 (Figure 3), usually in the lateral hind claw (Rusterholz, 1920; Dirksen, 2002). This is vertical positioned in the loading direction and thus extend the insertion of the deep digital flexor tendon at the distal phalanx (Lischer, 2000), the tuber flexor. Only in rare cases it can also move forward to the medial claws (Dirksen, 2002).



Figure 2 Pododermatitis septica circumscripta

Horn production then ceases over a very small 'circumscribed' area. This, in turn, causes a hole to develop in the sole through which granulation tissue (proud flesh) will protrude. This is often only visible during claw trimming. Subclinical laminitis is associated with the production of softer than normal horn (Raven, 1989). When this happens, the sole of the claw wears more rapidly than normal. Consequently, the sole is thinner and flatter than normal, making the 'typical place' prone to trauma. Laminitis also leads to damage of the suspensory apparatus of the digita and support system of the pedal bone with subsequent displacement (sinking/rotation) of the pedal bone. This may account for slight variations in the location at which the pedal bone sinks. As a result there is a broad variety of ulcers of different size and located at slightly different sites.

Within this disorder, the progress and severity of lameness are variable. In tie stalls, the hind toes may be rested on the edge of the curb of the stall in an attempt to relieve the pain. On flat surfaces, an affected animal will stand with the hind limbs camped back. Some cows may shake the affected foot frequently. When both hind feet are affected, the cow may continually shift weight from limb to limb and frequently lie down. PSC can be concealed below a layer of horn which may be discolored. There are two types to distinguish; an open and a closed ulcer. If the cow does not react to pressure on the discolored area of the sole, the lesion should be considered closed. Than it has not reached a point at which preventive treatment is likely to be unsuccessful. If the lesion responds to pressure, it should be considered as being open and loose horn will have to be removed (Figure 2).

#### Cause

Main cause of this claw disorder is seen in mechanical overload of the sole area. This destroys the horn-producing tissue between the flexor process of the pedal bone and the inside of the sole (Livesey, 1998; Dietz and Heyden 1990). Unequal load during walking, with load peaks in the area of the hind claw, leads to reactive hyperplasia of the claw (Toussaint Raven, 1973). Overloading of the claws causes proportion changes of the claw as long front wall, high abaxial side wall, high front sole area and low ball height (Dirksen 2002).

#### Treatment

Treatment must be aimed at trimming the sole. If the granulation tissue protrudes beyond the surface of the sole, it should only be removed to the level of surrounding tissue. This support de cells of the living epidermis to invade the surface of the granulated area from the periphery. If the PSC is a deep lesion, it needs protection. This can be reached by a plastic bag held in position with duct tape. The purpose is to avoid increasing pressure on the lesion itself.

### **3. Materials and Methods**

#### **3.1 Materials**

The research project was performed around Bern, Switzerland in the period between February and May 2013. During this period, 21 dairy farms connected to the herd health medicine of the ruminant clinic in Bern were visited. Most of the dairy farms were visited by two persons at the same time to limit subjectivity. We evaluated the claw health and disease on the farms while being assisted by hoof trimmers. Farm size had a range between 6 and 57 cows, with an average size of 21 cows. Most of the farms had Holstein Friesian cows and some farms had a small number of cross-breeds (Montebeliarde, Swedish Red, Danish Red, Jersey and Brown Swiss).

On the dairy farms, paper forms with the Locomotion Scoring System (*Appendix 1*) and the Hygiene Scoring System (*Appendix 2*) were used for the recordings. A tape- measure was used to measure certain stall dimensions and a digital photo camera was used to record barn and claw characteristics. An IPad with the program ‘Claw manager’ (Klaufenmanager®, a software program developed in Austria) was used to register the prevalence of claw disorders. Also parameters including animal housing and management systems, typical for current dairy farms in Switzerland were analysed.

#### **3.2 Methods**

##### ***Study team***

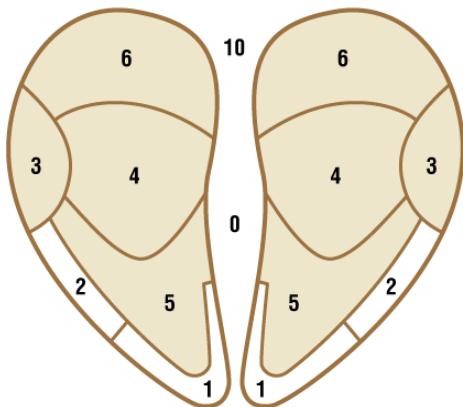
The study team consisted of: Joëlle Dietrich (Faculty of Veterinary Medicine, University of Bern, Switzerland), Töni Gujan (Faculty of Agronomy, University of Zürich, Switzerland) and Rianne van Helden (Faculty of Veterinary Medicine, University of Utrecht, The Netherlands).

##### **3.2.1. Data collection**

In advance of the visit, the farmers were asked to fill out a questionnaire regarding farm operating data, housing, feeding, pasture management, and other information. During the farm visit we noticed the boxes' measurements and documented the hygiene and locomotion scores. In addition, the dairy farms were visited when the usual hoof trimming was being performed. We collect data from each cow regarding the state of the claws by using the ‘Claw manager’ (see Figure 3.1), the lameness score and any noteworthy features or peculiarities were collected photographically. The two claw disorders EU and PSC were classified to the degree of severity (1-3) (*Appendix 3*).

All 21 dairy farms were listed in a database, as well as recording lesions. We administered a six-page questionnaire included items pertaining to farm characteristics (cadastral zone, breed, herd size, housing, bedding management and pasture access), hoof health management (trimming routine) and nutrition (feeding management).

After visiting each farm, we wrote a visit protocol containing lameness and hygiene scores, etc, and conducted a statistical analysis of all data. Finally, we reported farm-specific recommendations.



**Figure 3** Different zones of the claw as represented by the program 'Claw manager'

### 3.2.2. Analysis and statistics

After collecting the data on the farms using the 'Claw manager' and the hygiene- and locomotion scoring systems, the separate items were statistically analyzed using Excel 2007 and IBM SPSS statistics 20. This study can be characterized as a cross-sectional observational study for prevalence estimation. The observational unit is the individual dairy farm.

Claw health was assessed in terms of prevalence rates for both claw disorders. Prevalence rate was calculated as the proportion of claws with the outcome of a given claw disorder. In addition to cow level prevalence, herd prevalence rates were calculated for EU and PSC. Associations between different risk factors and the occurrence of EU and PSC scores were estimated using a binomial distribution and a logistic link function (generalized linear regression model for grouped data) in SPSS. First, a primary screening (univariate analysis) was performed to identify exposure variables related to EU and PSC (chi-square test, two-sided,  $P < 0.25$ ). Then, a multivariable model was obtained using a backwards-elimination procedure in SPSS until only variables (or group of dummy variables) with  $P \leq 0.05$  remained. Potential confounders re-entered the model. Odds ratios (OR) were calculated, indicating the estimated risk for the outcome of a claw disorder at a certain risk factor, relative to the estimated risk factor at the reference category (OR = 1). Different reference categories were chosen based on predominance. Associated  $P$ -values were calculated to test whether or not odds of claw disorders differ significantly between the reference category and other categories. Results were expressed as OR and 95% confidence intervals (CI). For all analyses, differences were considered significant when  $P \leq 0.05$ .

## 4. Results

### 4.1 Descriptive statistics

**Table 1**

**Number of dairy farms visited, number of cows trimmed, number of claws trimmed and the mean percentage of diagnosed *erosio ungulae* and *pododermatitis septica circumscripta***

Number of dairy farms	Number of cows trimmed	Number of claws trimmed	% Erosio ungulae	% Pododermatitis septica circumscripta
21	458	1832	49	1,6

**Table 2**

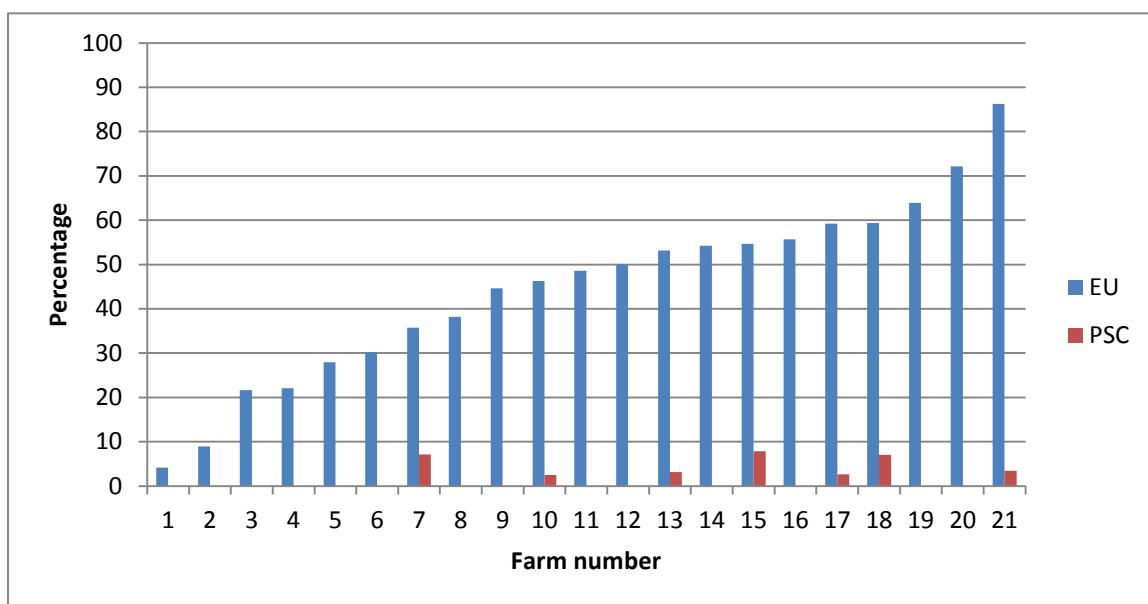
**The minimum, maximum, and mean numbers and standard deviation (SD) of the herd size and the number of claws per dairy farm**

	Minimum	Maximum	Mean	SD
Herd size per dairy farm	6	57	21	12
Number of claws per dairy farm	24	228	87	50,7

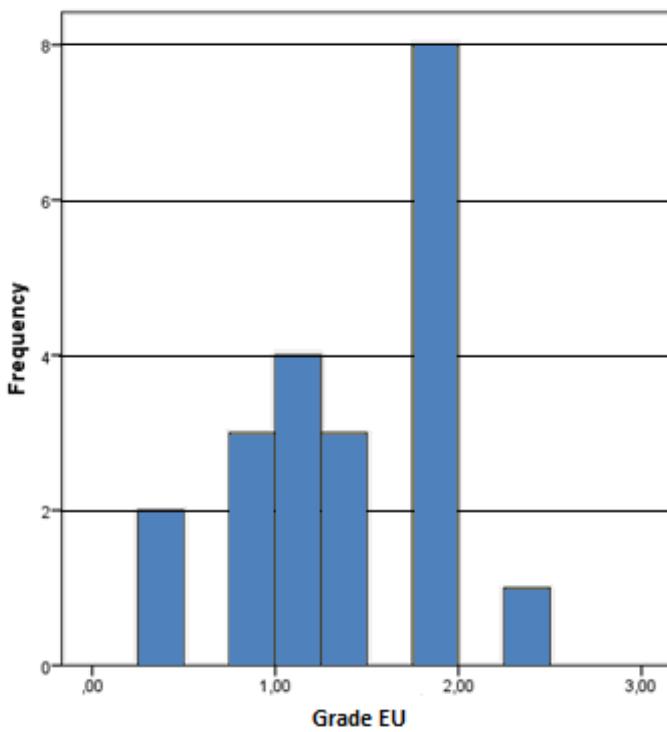
**Table 3**

**The minimum and maximum hygiene- and locomotion score per dairy farm**

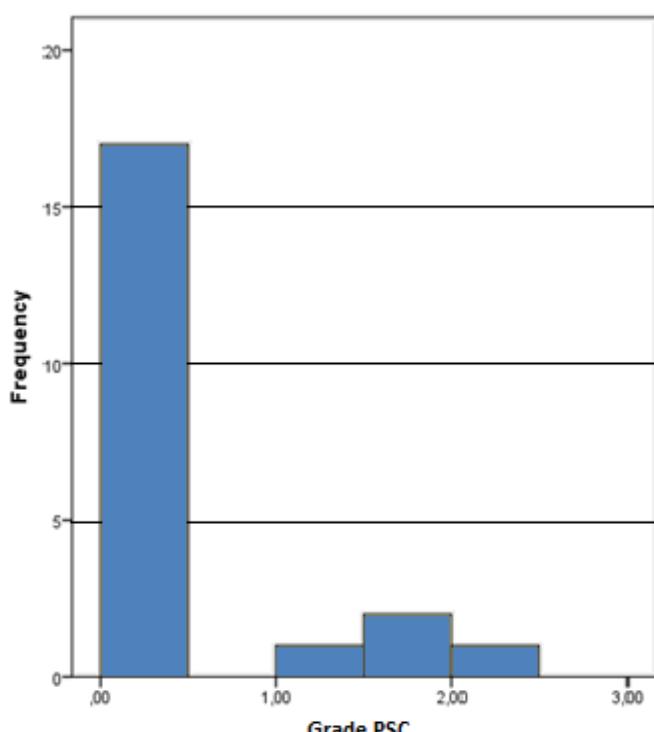
	Minimum	Maximum
Hygiene score per dairy farm	0,21	1,67
Locomotion score per dairy farm	1,10	2,21



**Figure 4 Distribution of the percentage of *erosio ungulae* (EU) and *pododermatitis septica circumscripta* (PSC) per claw over the different farms examined.**



**Figure 5 Frequency distribution of the *erosio ungulae* grade (Grade EU) over the different farms (N = 21). Mean grade = 1.38, SD = 0.55.**



**Figure 6 Frequency distribution of the *pododermatitis septica circumscripta* grade (Grade PSC) over the different farms (N = 21). Mean grade= 0.35, SD = 0.68.**

## 4.2 Erosio ungulae risk factors

**Table 4**

Significant ( $P \leq 0.05$ ) risk factors (frequency, prevalence) for *erosio ungulae* after applying the logistic-regression model. Odds ratio (OR), 95% Confidence interval (CI); lower and upper value,  $P$ -value

Risk factor	OR	95% CI		$P$ -value
		Lower	Upper	
<b>Cadastral zone</b>				
<b>Lowlands</b> 12(57.1%)	Ref.	-	-	-
<b>Pre-alpine</b> 5(23.8%)	2.40	1.59	3.61	.01
<b>Mountain zone 1</b> 2(9.5%)	.27	.16	.46	.01
<b>Mountain zone 3</b> 2(9.5%)	1.74	1.07	2.83	.03
<b>Housing</b>				
<b>Tie-stall</b> 17(81%)	Ref.	-	-	-
<b>Cubicles</b> 4(19%)	3.52	1.67	7.42	.01
<b>Bedding</b>				
<b>Straw + concrete</b> 2(9.5%)	.03	.01	.07	.01
<b>Rubber mat + straw</b> 19(90.5%)	Ref.	-	-	-
<b>Manure</b>				
<b>Remove &lt;1x/day</b> 2(9.5%)	.14	.06	.29	.01
<b>Remove &gt;1x/day</b> 19(90.5%)	Ref.	-	-	-
<b>Quantity litter</b>				
<b>Enough</b> 12(57.1%)	Ref.	-	-	-
<b>Few</b> 4(19%)	.38	.26	.58	.01
<b>Deficient</b> 5(23.8%)	.16	.08	.33	.01
<b>Breed</b>				
<b>Holstein</b> 10(47.6%)	Ref.	-	-	-
<b>Holstein + other breed</b> 8(38.1%)	2.98	1.66	5.36	.01
<b>Other breed</b> 3(14.3%)	.31	.18	.54	.01
<b>Biotin</b>				
<b>No</b> 15(71.4%)	4.15	2.50	6.89	.01
<b>Yes</b> 6(28.6%)	Ref.	-	-	-
<b>Trimming frequency</b>				
<b>1x/year</b> 8(38.1%)	2.39	1.59	3.62	.01
<b>2x/year</b> 11(52.4%)	Ref	-	-	-
<b>Method</b>				
<b>Grater</b> 2(9.5%)	.24	.12	.48	.01
<b>Grinder</b> 19(90.5%)	Ref.	-	-	-
<b>Perception</b>				
<b>Claw health first priority</b> 2(9.5%)	3.04	1.35	6.83	.01
<b>Claw health third priority</b> 12(57.1%)	Ref.	-	-	-

**Table 5**  
**Not significant ( $P > 0.05$ ) risk factors for *erosio ungulae* after applying the logistic-regression model**

Risk factor	P-value
<b>Pasture access in summer</b>	.9
<b>Quantity litter</b>	.7
<b>Hoof trimmer achiever</b>	.34
<b>Trimming frequency: &gt;2x/year</b>	.06
<b>Perception: Claw health second priority</b>	.10

### 4.3 Pododermatitis septica circumscripta risk factors

**Table 6**

Significant ( $P \leq 0.05$ ) risk factors (frequency, prevalence) after applying the logistic-regression model. Odds ratio (OR), 95% Confidence interval (CI); upper and lower value,  $P$ -value

Risk factor	OR	95% CI		$P$
		Lower	Upper	
<b>Cadastral zone</b>				
<b>Lowlands</b> 12(57.1%)	Ref.	-	-	-
<b>Pre-alpine</b> 5(23.8%)	5.86E-006	-17.15	-6.94	.01
<b>Mountain zone 1</b> 2(9.5%)	3264.25	2.97	13.21	.01
<b>Mountain zone 2</b> 2(9.5%)	340552523523 186760000000	61.09	61.09	.01
<b>Housing</b>				
<b>Tie-stall</b> 17(81%)	Ref.	-	-	-
<b>Cubicles</b> 4(19%)	101185885651 620720000	40.44	51.68	.01
<b>Bedding</b>				
<b>Straw + concrete</b> 2(9.5%)	2.58E-012	-32.81	-20.56	.01
<b>Rubber mat + straw</b> 19(90.5%)	Ref.	-	-	-
<b>Manure</b>				
<b>Remove &lt;1x/day</b> 2(9.5%)	2.30E-013	-35.58	-22.62	.01
<b>Remove &gt;1x/day</b> 19(90.5%)	Ref.	-	-	-
<b>Quantity litter</b>				
<b>Enough</b> 12(57.1%)	Ref.	-	-	-
<b>Few</b> 4(19%)	245925691467 020130000000 00	55.28	61.65	.01
<b>Deficient</b> 5(23.8%)	976493952896 9804000	39.10	48.35	.01
<b>Quality litter</b>				
<b>Clean</b> 9(38,1%)	Ref.	-	-	-
<b>Behind dirty</b> 13(61,9%)	8.66E-027	.	.	.
<b>Pasture</b>				
<b>No</b>	Ref.	-	-	-
<b>Yes</b>	1.51E-0161	-39.52	-33.33	.01
<b>Breed</b>				
<b>Holstein</b> 10(47.6%)	Ref.	-	-	-
<b>Holstein + other breed</b> 8(38.1%)	.01	-11.24	-6.56	.01
<b>Other breed</b> 3(14.3%)	938895255449 684	29.46	39.49	.01
<b>Biotin</b>				
<b>No</b> 15(71.4%)	93668	8.38	14.51	.01
<b>Yes</b> 6(28.6%)	Ref.	-	-	-

Trimming frequency				
<b>1x/year</b> 8(38.1%)	232231250941 9852	32.29	38.48	.01
<b>2x/year</b> 11(52.4%)	Ref.	-	-	-
<b>&gt;2x/year</b> 2(9.5%)	217306582869 558700000	40.69	52.97	.01
Achiever				
<b>Farmer</b> 6(28.6%)	2.86E-012	-29.95	-23.21	.01
<b>Professional hoof trimmer</b> 15(71.4%)	Ref.	-	-	-
Perception				
<b>Claw health first priority</b> 2(9.5%)	2.33E-015	-40.57	-26.81	.01
<b>Claw health second priority</b> 7(33.3%)	8073.35	6.65	11.34	.01
<b>Claw health third priority</b> 12(57.1%)	Ref.	-	-	-

## 5. Discussion

### Claw disorders

In this study two claw disorders were observed; EU and PSC. Figure 4 represents the percentage of EU and PSC on the 21 dairy farms. EU is a common claw disorder at every dairy farm (100%) as shown in the graph. PSC on the other hand, was only observed at 7 out of the 21 dairy farms (33.3%). In total, 49% of the claws had EU, whereas 1.6% of all the claws in this study had PSC (Table 1). The severity of both claw disorders was graded and the frequency distribution of these grade levels is demonstrated in Figure 5 and 6. Although the severity of both diseases is within the same range (0-2.5), they are different with regard to the frequency. A rather severe grade of EU (almost 2), corresponds with a frequency of 8 (Figure 5), whereas a very low grade of PSC (0-0.5), has a rather high frequency (Figure 6). EU had an average severity grade of 1.38 on a scale from 1 to 3, PSC had an average severity grade of 0.35. Because of the small prevalence of PSC on the dairy farms examined, the results in Table 6 are not suitable for further analysis in that the odds ratio (OR) for almost every risk factor was either very high or extremely low.

### Methods

#### 5.1 Study population

The average herd size of 21 dairy cows in this study (Table 1) was higher than that of dairy farms participating in the Swiss milk recording system, which average herd contains 17 cows (Reneau, 2007). The smallest dairy farm examined had 6 cows whereas the biggest dairy had 57 cows (Table 2). The impression is that despite the rather small population study, the dairy farms included represent very well Swiss dairy farms, and as a result, our findings reflect the current situation with respect to claw health in dairy cows in Switzerland.

#### 5.2 Insignificant findings

As shown in Table 4, almost every risk factor for EU gives a significant correlation except with regard to pasture ( $P = 0.9$ ), quantity of the litter ( $P = 0.7$ ), the achiever of the hoof trimming ( $P = 0.34$ ), trimming frequency  $>2x/year$  ( $P = 0.6$ ) and the perception of the farmer; claw health second priority ( $P = 0.10$ ) (Table 5). A reason for the lack of significant correlations with these items could be the relatively low number of farms on which these items could be scored. There were barely dairy farms without summer grazing (43%), bad quality litter at the lying area (24%) and a person other than a professional hoof trimmer for his cows (29%). Overall, it can be concluded that a relatively high percentage of the chosen risk factors on a dairy farm correlated with EU. In the model grazing was not associated with EU. This is contrary to Gustafson (1993) who found that exercise compared with tied conditions had a positive effect on the health of the cows' legs around calving. Gustafson's study was an experiment aiming at showing the influence of daily exercise on the cows' health. An eventually positive influence from daily exercise was leveled out by negative influence from, for example, stones bruising the hooves. It is the author's belief that exercise probably has a positive impact on the health of the cow's leg, but to be so the exercise area should be in proper condition.

### **5.3 Scoring subjectivity**

Although on all farms all cows were scored by the same scoring system and by the same three persons, scoring remains subjective. Besides that, the circumstances in which EU was scored could not always be exactly the same due to variation in times of visits and work on the farms. Another thing to take into account is that it was a cross-sectional study; all the farms were visited only once, and consequently the scored percentages of EU could of course vary between months, for example due to weather conditions.

### **5.4 Number of farms examined**

We visited 21 dairy farms, which might be too few to obtain more significant correlations than we have shown. However, some risk factors were not present at all farms and were therefore excluded from the study. For example, the presence of claw bathes. Another reason for excluding some risk factors was that the questionnaire was not always filled in completely by all farmers.

## **Risk factors for EU**

### **5.5 Cadastral zone**

A significant correlation was found between the prevalence of EU and the cadastral zone where the dairy farm was located. The percentage of EU on a dairy farm was higher when the dairy farm was located in the pre-alpine zone ( $OR = 2.40$ ) or in the mountain zone 3 ( $OR = 1.74$ ) and lower in the lowlands (Ref.) and in the mountain zone 1 ( $OR = 0.27$ ). This was unexpected, because the category pre-alpine is not followed by the category mountain zone 3 and the category lowlands is not followed by the category mountain zone 1. The main explanation of these unexpected results would be that it is unknown where the cows of the dairy farms graze in the summer, because the location of the farm tells nothing about the cadastral zone where the cows are grazing. The cadastral zone could be important for contracting EU, because it determines the circumstances and therefore the exposure and attrition of the claws for a large period of the year. Somers et al., 2005 found that the OR for EU is lower when cows are grazing on mixed soil.

### **5.6 Method of hoof trimming**

Another important factor in EU prevention is the method of hoof trimming. There is a significant correlation between the kind of tool used during the hoof trimming and the prevalence EU on a dairy farm. The percentage EU decreased when a grater ( $OR = 0.24$ ) was used compared to a grinder (Ref.). We must take into account that there were only 2 dairy farms that used a grater versus 19 dairy farms that used a grinder. No literature is available to my mind about the association between the kind of tool used and the prevalence of EU. One explanation may be that when the grater is used, the achiever spend more time on trimming and is working more careful than when the grinder is used.

### **5.7 Trimming frequency**

There was a significant correlation between the frequency of hoof trimming and the percentage of EU. The OR for hoof trimming once a year was 2.39 compared to the reference category (twice a year). Claw trimming is the only treatment for serious EU, although it has been suggested that minor lesions of EU can heal spontaneously (either at pasture or at the end of lactation) (Peterse, 1985; Toussaint Raven et al., 1985; Maton, 1987). Somers et al., 2005 reported also that herd trimming at long intervals was associated with an increased OR for EU. The goal of preventive trimming is to promote balanced loading by increasing the weight-bearing contact area of the claws thereby improving the balance between medial and lateral claw (Tol et al., 2004). Hoof trimming as part of the farm management, can be used either as a preventive or curative tool. If farmers have done the hoof trimming in order to prevent serious claw problems, this might result in underestimation of the prevalence rates for certain claw lesions. When farmers may pay less attention to their cattle's claw health, allowing a longer time period between two herd trimmings, this might result in an overestimation.

### **5.8 Housing**

A significant correlation between the items housing and EU was found. Cows exposed to a tie-stall showed lower prevalence rates for EU lesions than cows in a free, cubicle housing system ( $OR = 3.52$ ). A lower OR in a tie-stall housing system versus cubicles, was also reported by Bergsten et al., 1996 and Manske et al., 2002. That has probably to do with the different kind of floor and its cleanliness. Bergsten et al., 1996 also reported that EU was reduced after introducing a footbath. In this study, none of the dairy farms used footbaths and therefore this risk factors could not further be investigated. Sogstad et al., 2005 confirmed that EU was more prevalent in free-stalls than in tie-stalls.

### **5.9 Bedding**

A significant correlation was found between the kind of bedding and EU was found. A bedding of straw on a concrete floor resulted in a lower OR ( $OR = 0.03$ ) than a rubber mat with straw (Ref.). This could be important for the degree of EU, because it might be associated with the lying behavior of the cows; cows will spend more time on lying when the surface is soft (Cook et al., 2009). We must take into account that there were only 2 dairy farms with straw on concrete floors versus 19 dairy farms with straw on a rubber mat.

### **5.10 Manure**

EU incidence increased when the manure was removed more than once a day and decreased when the manure was removed less frequently ( $OR = 0.14$ ). This result was unexpected, because moist claw environment combined with manure exposure is regarded as the major determinant of EU (Enevoldsen et al., 1991). In particular, the use of a manure scraper may reduce these adverse effects. Also Bergsten and Pettersson, 1992 and Hultgren and Bergsten, 2001 reported that cows housed on floors without scraper had a higher odds than those who had one. The explanation of our results was conducted in mostly tie-stall housing systems and therefore the manure is only in the back of the lying area. Also is unknown what the interpretation of the farmer for this question really is. Removing the manure behind the lying area, from the gutter, or does he remove the manure from the lying area. In the first case, the frequency of removal of the manure has nothing to do with the exposure to the claws to manure. We must take into account that there were only 2 dairy farms that removed the manure less than once a day versus 19 dairy farms that removed the manure more frequently.

### **5.11 Litter quality**

The quantity of the litter in the lying areas was significant correlated with the percentage of EU. When there was enough litter (Ref.), the percentage EU on a dairy farm was higher, than when there was much less litter ( $OR = 0.38$ ) or deficient ( $OR = 0.16$ ) litter. An explanation of this could be that when there is enough litter, the moisture of the litter is higher in contrast to deficient litter, where the urine drains to the back.

### **5.12 Breed**

There was a significant correlation between breed and the prevalence of EU on the dairy farms. The percentage EU increased when besides Holstein another breed was present ( $OR = 2.98$ ) and decreased when there was only another breed than Holstein present ( $OR = 0.31$ ). Peterse, 1985 reported that other breeds than Holstein, like Montbeliarde and Jersey are less lameness (claw disorder)-susceptible breeds. Enevoldsen et al, 1991 found that body weight was positively associated with PSC.

### **5.13 Perception**

There was a significant correlation between the perception of EU problems and the real prevalence of EU on a dairy farm. Farmers that did have a high prevalence of EU (Table 4,  $OR = 3.04$ ) said that claw health was a problem (first priority). There were also farmers saying that claw health had a low priority (claw health third priority) and do have EU (Ref.). This indicates that some farmers may underestimate the prevalence of EU on their farms. Several other studies also found that farmers underestimate lameness prevalence compared with researchers (Whay et al., 2002; Sarova et al., 2011).

## 6. Conclusion

Correlations between PSC and the several risk factors could not be investigated in a proper way because of the very low prevalence of this claw disorder on the dairy farms examined. In contrast, correlations between EU and risk factors could be investigated very well and led to interesting results. In the latter case, only few correlations were not significant, like pasture access in summer, the litter quality and the hoof trimming achiever. The trimming frequency appeared to be important for EU, as well as feeding biotin and the use of a grater appeared to have a positive influence on EU. Also the questionnaire revealed positive correlations between EU perception and incidence, as well as housing risk factors. The awareness of farmers concerning EU has to be increased. When a farmer recognizes EU as a problem, he will take proper actions to improve claw health and thus, animal welfare. This study shows that management factors can significantly contribute to reducing the occurrence of EU. For example, by raising other breeds than Holstein Friesian. There were some unexpected findings, for example the risk for EU was smaller when the manure was removed less frequently a day and also when the amount of bedding was deficient.

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## 9. Appendices

### 9.1 Appendix 1: Locomotion score

Locomotion scoring system used to determine herd lameness prevalence (Specher et al, 1997).

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Locomotion Score	Clinical description	Assessment criteria
1	Normal	The cow stands and walks with a level-back posture. Her gait is normal.
2	Mildly lame	The cow stands with a level-back posture but develops an arched-back posture while walking. Her gaits remains normal.
3	Moderately lame	An arched-back posture is evident both while standing and walking. Her gait is affected and is best described as short striding with one or more limbs.
4	Lame	An arched-back posture is always evident and gait is best described as one deliberate step at a time. The cow favors one or more limbs/feet.
5	Severely lame	The cow additionally demonstrates an inability or extreme reluctance to bear weight on one or more of her limbs/feet.

## 9.2 Appendix 2: Hygiene score

Hygiene scoring system used to determine herd hygiene prevalence (Reneau et al., 2005).

Category identification	SCORE				
	1	2	3	4	5
 Tail head					
 Upper rear limb					
 Ventral abdomen					
 Udder					
 Lower rear limb					

### 9.3 Appendix 3: Claw score

Claw scoring system used to determine the severity of *erosio ungulae* and *pododermatitis septica circumscripta* per claw (Karl Burgi and Nigel B. Cook, abc hoof lesion scoring system).

Severity	<i>Erosio ungulae</i>	<i>Pododermatitis septica circumscripta</i>
Mild (1)		
Moderate (2)		
Severe (3)		