Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Fakulteten för landskapsplanering,
trädgårds– och jordbruksvetenskap

Effect of grazing and housing system on dairy cows´ hygiene, claw and leg health

Inverkan av bete och stallsystem på hygien, klöv- och benhälsa hos mjölkkor

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CONTENT

SAMMANFATTNING

Enligt den svenska djurskyddslagen ska mjölkkor hållas på bete sommartid. Före 15 juni 2012 skulle betesperioden förläggas under en sammanhängande period på 2-4 månader, efter detta datum har lagen ändrats så att perioden kan delas upp. Bete har många goda effekter på bland annat hälsa och naturligt beteende, men kan också innebära problem med kotrafik i robotsystem och svårigheter att få ut stora besättningar på tillräckligt bra bete. Detta examensarbete består av två delar, dels en studie av hur betestiden inverkar på hygien, klöv- och benhälsa på fyra gårdar med robotsystem och dels en enkätstudie där tillämpning av olika stallsystem och betesrutiner utvärderades.

I robotstudien gjordes bedömningar av hygien och benhälsa ute på gårdarna vid två tillfällen, under och efter betet. Tiden på bete registrerades på olika sätt och effekter på klövhälsa (eksem, digital dermatit, klövröta, sulblödningar och klövsulesår) som registrerades med hjälp av klövhälsorapport, analyserades på två gårdar.

Gårdstudien visade att på en av de gårdar som analyserades hade kor som gått på bete hälften så hög andel anmärkningar på klövröta (P≤ 0.05) som de som ej gått på bete vid verkningen. Skillnaderna för andra klövsjukdomar var mindre och ej statistiskt signifikanta. Hygienen på flanken hos kor som gick på bete var bättre (P≤0.05) jämfört med dem som ej gått på bete.

I enkätstudien telefonintervjuades 176 lösdriftsbesättningar som hade gjort klövhälsoregistreringar på våren innan och hösten efter betesperioden. Man kunde se skillnader i prevalensen för olika klövhälsoanmärkningar bland annat beroende på antal dagar på bete, beteszon, besättningsstorlek, ras och golvtyp. Det totala antalet anmärkningar på hösten var högre för kor som gått färre än 138 dagar på bete (p≤0.05) och för kor i beteszoner med kortare lagstadgad beteslängd (p≤0.05). Kor i besättningar med mer än 200 kor hade lägre prevalens totala anmärkningar (p≤0.05) jämfört med mindre besättningar. SRB-kor hade högre prevalens (p≤0.05) totala klövhälsoanmärkningar på våren jämfört med Svensk Holstein (SH), dock fanns ingen skillnad på hösten efter betet. Kor på gummimatta hade högre prevalens klövröta vid vårverkning jämfört med kor på betonggolv (p≤0.05). Det framkom att 80 % av de tillfrågade mjölkproducenterna tyckte att betesdriften fungerade tillfredställande i deras besättning.

ABSTRACT

According to the Swedish animal welfare legislation, Swedish dairy cows shall be kept on pasture during the summer. Before June 15th 2012 cows had to be on pasture for a continuous period of time, 2-4 months depending on region. Today the legislation has changed and the period can be divided. Grazing has many beneficial effects, for example on health and natural behavior, but it may also involve problems with cow traffic in automatic milking systems (AMS) and difficulties to provide quality pasture for large herds. This master thesis have two parts, one study where the effects of grazing time on hygiene, claw-and leg health on four farms with AMS was studied, and one questionnaire study where the effects of grazing and stall environment of 176 farms were assessed.

In the Robot study, evaluation of hygiene and leg health was made during and after grazing. Time at pasture was recorded and the effects on claw health (dermatitis, digital dermatitis, heel horn erosion,

sole hemorrhages and sole ulcers) were analyzed in two farms. Claw health was noted by the claw trimmers and later retrieved from the national claw health report.

At farm number three, cows that were grazed had half as many remarks of heel horn erosion compared to the non-grazing group ($P \leq 0.05$) at the time of trimming. There were no differences in prevalence for other claw lesions. The hygiene on the flank was better for grazing groups than non-grazing groups ($P \leq 0.05$).

In the Questionnaire study 176 cubicle herds that had claw reports from the spring trimming before and the autumn trimming after the grazing season, were telephone interviewed. Differences in the prevalence for claw health remarks was found for: number of days at pasture, grazing zone, herd size, breed and type of flooring. The total prevalence of remarks in the autumn was higher for cows that had been grazed less than 138 days ($p \leq 0.05$) and for cows in zones with shorter prescribed pasture period ($p \leq 0.05$). Cows in herds with more than 200 cows had a lower prevalence of total remarks at autumn trimming ($p \leq 0.05$) compared to smaller herds. Swedish Red (SR) had a higher prevalence ($p \leq 0.05$) of total remarks in the spring compared to Swedish Holstein (SH); however there was no difference in the autumn trimming. Cows on rubber flooring had a higher prevalence of heel horn erosion in spring compared to cows on concrete ($p \leq 0.05$). It was found that 80 % of the interviewed farmers believed that the pasture management worked satisfactory in their dairy herds.

INTRODUCTION

Swedish dairy cows shall, according to the Swedish animal welfare legislation, be kept on pasture during the summer and the length of the pasture period shall be 2-4 months (depending on region). Before June 15th 2012 the entire pasture period had to be continuous and take place between May 1st and October 15th (SJV, 1988). Today the period can be divided (if a pasture plan is presented) and the dates are changed. Continuous pasture for a minimum of 60 days is still prescribed. The regulations for heifers on pasture are also changed and they may stay indoors for 45 days during insemination and pregnancy control (SJV, 2012). Cows on pasture must come out on to the pasture daily and they are required to have access to the pasture during at least 6 hours per day during this period (SJV, 2010).

Pasture is beneficial for claw- and leg health (Hernandez- Mendo *et al.,* 2007; Olmos *et al.*, 2009), natural behavior (Redbo, 1990) and hygiene (Ellis *et al.* 2006). There is also a consumer aspect, the desire that cows should be on pasture during the summer (Nordström, M., personal communication 2012). Cows provided with the choice between cubicle housing and pasture chose to spend approximately 13 hours per day on pasture, mainly during the night (Legrand *et al.*, 2009).

During many years the Swedish dairy farming has developed towards larger herds held in cubicle systems, often combined with automatic milking systems (AMS). More than 50 % of Swedish dairy cows are housed in cubicle systems (Svensk Mjölk, 2011a).

Although there are many positive effects of grazing dairy cows there are also problems, which may reduce the benefit and motivation for grazing such as lack of suitable pasture in large herds, bottle necks in passages, wet grounds leading to hygienic problems (von Wachenfeldt, 1997) or long walking paths to pasture. Passage ways must be firm to resist loading, sloped to resist surface water at rainfall and drained. Firm (concrete) outdoor areas may need cleaning if contaminated with manure just as alleys indoors. Feed consumption may be reduced on pasture (Legrand *et al.* 2009) leading to weight loss or reduced yield. Cows in automatic milking systems may also develop routines like walking to and especially from pasture together in a flock, which will cause bottlenecks and cows waiting at the robot.

The objective of these studies was to answer the following questions:

- Does the grazing time in cubicle housing systems have any effect on claw- and leg health and hygiene of dairy cows?
- Will cows improve claw health better with a continuous grazing period compared to an interrupted, but with comparable length?
- How do housing environment and cow factors affect claw- and leg health and hygiene of dairy cows?

Extended studies on the subject have provided a basis for changes in the Swedish animal welfare regulations of grazing for dairy cows.

LITERATURE REVIEW

Claw lesions

Interdigital phlegmon

Interdigital phlegmon is caused by an infection with *Fusobacterium necrophorum*, possibly preceded with trauma of the interdigital skin. The trauma can be caused by stones, pieces of wood, uneven grounds. Also a deterioration of the natural skin barrier from dermatitis, skin moisture or dry cracks can open an entry for the bacterium. The disease is more common in wet weather but can also occur under extremely dry conditions (Bergsten, 1997). Among loose housed animals, the risk of infection is increased with the elevated number of animal contacts (number of animals^{2} -1). Thus compared to tied cows, cows on pasture have a higher risk of interdigital phlegmon (Bendixen *et al.* 1986).

Interdigital dermatitis

Interdigital dermatitis (ID) is a bacterial infection, often caused by the bacterium *Dichelobacter nodosus*, which leads to an inflammation between the digits. It can develop into heel horn erosion (HE) and then cause severe lameness (Bergsten, 1997). Interdigital dermatitis/ heel erosion is sometimes (in the Netherlands) named IDHE as one condition (Somers *et al.* 2005b). *D. nodosus* can spread between cows via manure and the disease often develops in moist environments with poor hygienic conditions. Interdigital dermatitis is prevented by regular foot baths, claw trimming and most importantly by a clean and dry environment (Bergsten and Pettersson, 1992; Bergsten, 1997). The prevalence of interdigital dermatitis was higher in the later part of the housing season according to Andersson & Lundström (1981).

Digital dermatitis

Digital dermatitis (DD) was first reported by Cheli and Mortellaro (1974) and was first clearly diagnosed in Sweden in 2004 (Hillström & Bergsten, 2005). It is recognized as a circular, ulcerative sometimes wart-like lesion, often referred to as strawberry-like. In the acute phase it is painful when touching and results in lameness. In subclinical stages it can be impossible to distinguish from ID. The infection is caused by a spirochete of *Treponema* species. Many types of *Treponema* may cause DD and the more types simultaneously occurring the more severe clinical symptoms (Klitgaard, 2008). The condition is contagious and important actions to prevent spreading of DD are to keep infected cows away from healthy, provide footbaths and a clean, dry environment. Digital dermatitis is locally treated with antibiotics or disinfectants. Salicylic acid powder under a wrap is often used as a non-antibiotic topical treatment.

Heel horn erosion

Heel horn erosion was also found to be more common during the later part of the housing season (Andersson & Lundström, 1981) and considered to be caused by contagious environment with high humidity (Collick, 1997). When animals are affected with dermatitis new heel horn production is inhibited and a V shaped lesion is developed. When the dermatitis heals, new horn is formed and the bulbs are successively restored. To reduce the prevalence of heel horn erosion, the dermatitis must be prevented and cows shall be provided with dry, clean flooring and bedding. Grazing during the summer

is beneficial (Collick, 1997). According to Bergsten and Pettersson (1992), heel horn erosion was significantly higher among cows exposed to a dirtier stall environment. Moreover, cows with electrical cow trainers had cleaner stalls and claws and had lowers scores for heel-horn erosion. Moist and dirty environment are important factors increasing the occurrence of heel horn erosion as there was a negative correlation between dry matter content of the sole horn and the degree of heel-horn erosion (Bergsten & Pettersson, 1992). High yielding cows in the beginning of the lactation have larger amounts and softer feces which may increase the risk of heel horn erosion.

Interdigital hyperplasia/ Limax

Interdigital hyperplasia is caused by chronic irritation of the interdigital skin from splaying of the digits or often dermatitis. A fibrous fold is formed in the interdigital space. It is more common in the hind limbs. Depending on the size of the lesion and the presence of infection or necrosis, interdigital hyperplasia may cause different degree of lameness. An increased incidence of interdigital hyperplasia has been seen in cubicle systems with automatic scrapers which tend to cover the claws in manure (Collick, 1997).

Sole hemorrhages and laminitis

Sole hemorrhages (SH) are caused by blood imbibation in the sole originating from sub-solar corium hemorrhages. These hemorrhages can be caused by trauma from hard concrete surfaces or rough stony track ways if the soles are thin by wear or over trimming. But, most commonly hemorrhaging is a result from a combination of metabolic, physiological and mechanical changes in the feet called laminitis. Laminitis is a multifactorial disease with risk factors such as feeding, environment, genetics, stage of lactation, milk yield etc. If the movement of the claw bone is extensive, because of metabolic alterations, and the ground is hard the corium is squeezed in between and injured. Sole hemorrhages increase the risk of sole ulcers and all other sole lesions (double sole, white line disease, toe ulcer (Greenough et al., 2007). SH is prevented by functional trimming before calving and the trimming has to be adapted to the given environment. When cows are kept on for example new concrete flooring they need a thicker sole. Keeping cows on rubber flooring or grass is the best prevention. To prevent laminitis possible metabolic risk factors must be eliminated (Bergsten, 2003).Sole Ulcer

Sole ulcer (SU) is an open connection through the sole that expose the corium at the posterior part of the sole. The ulcer is painful and the cow is commonly lame (Flower and Weary, 2006). Risk factors for sole ulcer are the same as for sole hemorrhages and laminitis related lesions. Sole ulcer is a claw disorder with huge impact on welfare because it is painful and long lasting. Changes from soft to hard environment, from pasture or straw pack to concrete, may be a risk factor (Bergsten, 2009). Because of welfare implications the sole ulcer needs immediate care to relieve the weight from the affected claw with the application of a block on the sound claw.

White line disease

The white line is the connecting, softer horn between the wall and sole horn. White line separation is commonly seen and does not normally cause lameness unless the separation involves the corium beneath. White line abscess (WLA) is when the corium is infected with a sub solar abscess without drainage. It may be caused by foreign bodies that penetrate the white line (Greenough, 2007). Walking

on hard, abrasive flooring and high pressure load may injure and infect the tissue beneath (Vermunt, 1990). The welfare implications and treatment is the same for WLA as for sole ulcer.

Double sole

Double sole is a condition where a "new" sole horn is developed under and separated from the previously formed sole horn. It is caused by a disturbance of horn formation due to laminitis (traumatic and or metabolic changes) or a sub solar abscess (Greenough, 2007).

Leg lesions

Hairless hocks and hock injuries are common in housed dairy cows and causes them discomfort and pain. In a study by Weary and Taszkun (2000), 73% of cows (in free stall systems) had at least one hock lesion and sixteen of the 20 farms studied had not had their cows on pasture for the previous 6 months before the study. Furthermore, hock injuries were more common among farms using geo-textile mattresses than farms with deep sand beds. Haskell et al. (2006) found that hock rubs (lesions), swellings and scratchings as well as knee rubs and swellings were more common in cubicle systems than in straw yards. They also found a correlation between injuries on cows´ legs and lameness. Hock lesions are also common in tied dairy cows, and when comparing tied cows that were allowed to exercise outdoors during the whole year with cows that only were allowed outdoors during the summer, Gustafson (1993) found that the prevalence of hock lesions was significantly higher in non-exercised cows.

Hygiene

Cow hygiene may be affected by stall design and management, stage of lactation (Ellis *et al.* 2006) and feeding. Zurbrigg et al. (2005) studied the effect of tie-stall design on cow health and cleanliness. They found that cows with dirty hind legs were more likely to have hairlessness of hocks. Ellis *et al*. (2006) found that cows were dirtier during the housing period and that nonorganic, high yielding cows were less likely to have a low hygiene score, meaning they were dirtier. Manske (2002) found that cows with dirty hooves had a higher prevalence of claw lesions at spring trimming.

Swedish claw and leg health in an international perspective

Claw health is recorded by the claw trimmer in about 50 % of Swedish dairy herds. The most common claw health remarks (dermatitis, digital dermatitis, heel horn erosion, sole hemorrhage and sole ulcer) are noted according to a color atlas (appendix 2). In 2011, 56 % of the recorded cows were without any remark. Over the last 5 years around 20% of the Swedish dairy cows included in the claw health statistics had heel horn erosion and sole hemorrhages, about 3 % had digital dermatitis and 7% had sole ulcers (see Table 9 in the Appendix).

Sweden was the first country to introduce routine claw health recording by claw trimmers and Denmark has recently commenced to use the same system with electronic records. Other comparative international statistics are not available although some regional records are kept in The Netherlands, Canada, Germany, Norway, and Finland among others (Bergsten, C., personal communication 2012).

Description of different management systems

The most relevant management systems for dairy cows have been described in a scientific report on animal welfare in relation to leg and locomotion problems from European Food Safety Authority (EFSA, 2009) and range from systems with a high grade of confinement (tie stalls) to systems based entirely on pasture. Systems with loose housed cows can include both straw yards and systems with cubicles and in some cases access to pasture or exercise areas. High yielding dairy cows have high nutrient demands, especially during the first four months after calving, and they need supplement feeding when grazed. Controlling the diet may be more difficult on pasture, but pasture can supply high quality forage, exercise and a wider possibility of expressing natural behavior.

Pasture based production

In for example Australia and New Zeeland most dairy production is pasture based and cows usually walk to a parlor in a shed for milking. As milk production is often based entirely on pasture the production is lower in these systems compared to systems where animals are supplemented with concentrates and roughage indoors. The NZ grazing systems are nowadays changing and animals in very big herds are also housed in cubicle systems during the winter period to protect the pastures from overgrazing/tramping. Keeping animals on concrete can result in severe lameness problems also in pasture based systems (Mason *et al*., 2012).

Zero grazing

Zero-grazing systems, where dairy cows are kept indoors permanently, are common in North America and in some parts of Europe. Zero-grazing is for example increasing in the Netherlands and Denmark and is very common in parts of southern Germany and Austria (van Vuuren & van den Pol-van Dasselaar, 2006).

The effects on lameness prevalence in zero grazing systems in for example Great Britain has been studied (Haskell *et al.*, 2006). Zero grazed dairy cows in cubicle housing systems were found to have more than twice as high levels of lameness as cows grazed during summer time. The study was made on 37 farms during the period November 2000 to April 2003, the first visits to farms being performed at least 3 weeks after the cows were brought indoors after pasture.

In a study by Herlin and Drevemo (1997) a locomotion analysis was made on a minor group of cows that were kept indoors (either tied up or in cubicles) for 2 ½ years, or were kept tied up or in cubicles during the winter season and allowed to graze for three months in the summer. The cows on pasture had increased flexibility of the hock compared to the cows kept indoors all year. They also found that cubicle housed cows that were zero-grazed were stiffer in their locomotion compared to all the other groups, possibly an effect of walking on slippery concrete flooring.

Pasture in Sweden

The Swedish legislation on animal welfare states that all dairy cows must have access to the pasture area during at least 6 hours per day during the grazing period, which length is dictated, depending on region, by the Swedish Board of Agriculture (SJV, 2012). In northern counties of Sweden grazing is mandatory in a period of 2 months while the period is 3 and 4 months in middle and southern counties, respectively (Table 1). If a pasture plan is presented, the pasture period can be divided, but a continuous

period of at least 60 days is prescribed. The most common arrangement for dry cows is to graze them 24 hours a day during the summer but sometimes cows are grazed either day or night.

Table 1 *Minimum time at pasture in months depending on region and pasture dates*

	Minimum time at pasture
Zone 1	4 months in Blekinge, Skåne and Hallands county. Pasture has to take place between April 1st- October 31st. Continuous pasture for 2 months between May 15th and September 15th.
Zone 2	3 months in Stockholms, Uppsala, Södermanlands, Östergötlands, Jönköpings, Kronobergs, Kalmar, Gotlands, Västra Götalands, Värmlands, Örebro and Västmanlands county. Pasture has to take place between April 1st- October 31st. Continuous pasture for 2 months between May 15th and September 15th.
Zone 3	2 months in Dalarnas, Gävleborgs, Västernorrlands, Jämtlands, Västerbottens and Norrbottens county. 30 days of the continuous 60 day period has to be between June 1st and August 31st. Pasture have to take place between May 1st and October 31st.

It is also common in northern Europe and the northern parts of America to let the cows out on pasture in the summer (Rushen *et al.*, 2008).

Organic farming and pasture in Sweden

KRAV, the Swedish association for organic farmers with certification of organic products, has extended regulations for dairy cows on pasture. All organic dairy cows have to be at grazed at least 12.5 hours per day during the summer. Forage intake on pasture shall be a minimum of 6 kg DM (KRAV, 2012). According to the EU regulations for organic dairy cows, it is allowed to have tied dairy cows in smaller herds if they are exercised twice a week (SJV, 2012). Tied dairy cows that were exercised (walked 400-3000 meters) outdoors every day around the year were found to improve their health compared to non-exercised tied cows (Gustafson, 1993).

The effect of pasture on claw health, lameness and hook injuries

Olmos *et al.* (2009) showed that cows need at least 85 days at pasture after calving to show less severe claw lesions and better locomotion than zero-grazed cows. After 85 days on pasture there was no or little further improvement in claw health. The grazed cows in this study were kept in cubicles before calving and then let out on pasture after calving.

Baird *et al.* (2009) found that cows on pasture with digital dermatitis had less heel erosion scores than zero-grazed cows with digital dermatitis housed in cubicles. They also found that cows in the pasture group had higher sole lesion scores and higher total lesion scores than cows in the indoor group. There was no difference in locomotion scores between the groups. Somers *et al.* (2005a) also found that cows that spent more days grazing had lower prevalence of digital dermatitis compared to cows that were less grazed, and that the effect of grazing also was seen during the housing period. Moreover, in another study by Somers *et al*. (2005b) twice as many animals had interdigital dermatitis and/or heel horn erosion when housed compared with the end of the pasture season.

Faye and Lescourret (1989) recorded the seasonal incidence of foot lesions at 80 French dairy farms during two years. They found no seasonal difference the first year, but the second year the foot lesion incidence was lower during the grazing period. The same study also found that cubicle housing had a more negative effect on claw health than tie stall housing.

A study made on dairy cows in New Zealand, which were on pasture all year around, found that the onset of lameness could be associated with wet weather. The number of rainy days and the number of new lame digits reported in the herds had a highly significant relationship. The most common claw conditions found in this study were sole hemorrhage and white line separation. Wet conditions and walking on hard surfaces were predisposing factors for white line disease (Tranter & Morris, 1991). Williams *et al.* (1986) also found a correlation between wet weather and lameness, lameness occurring approximately 3 weeks after rainfall.

In a British study comparing organic and conventional dairy herds, hook lesions were found to be less present in organic herds. The length of the grazing period in conventional herds did influence the prevalence of hook damage with longer grazing periods meaning a lower incidence of hook injuries. Housing system was also found to have an impact on the presence of hock injuries, where cows housed in cubicles had higher prevalence of hock injuries compared to cow housed in straw pens (Rutherford *et al*., 2008).

Passageways to and from pasture

Pathways leading to the grazing area have a considerable impact on claw health. This includes the construction as well as management and cow traffic. In a study made in New Zealand by Chesterton *et al.* (1989) several risk factors for lameness were studied. The maintenance of the main track, in this case leading from pasture to the milking shed and back, was one of the two most important factors linked to lameness. Other factors influencing the lameness prevalence was the width of the main track and the number of congestion points along the track. Factors that were found not to influence the lameness prevalence level were the length of the track, the slope of the track and the percentage of concrete or gravel of the track.

Faull *et al.* (1996) studied tracks leading to and from pasture. The walking surfaces were scored 1-5; 1 meaning very smooth and 5 very rough. The ideal walking surface was scored with 3. Although 70 percent of the outdoor walking surfaces were considered too rough, they could not relate this to higher incidence of lameness or impaired locomotion scores. The incidence of lameness was lowest at farms with track ways scored with 3. They also observed that cows were very selective if they could choose where to walk and that they created “cow walks”.

In a study made by von Wachenfeldt (1997) several materials for walkways to pasture were studied on 17 farms with approximately 120 cows each. A mixture of bark and sand as a top layer on the walkway was found to keep it dry and comfortable as well as providing the right friction. Unlike gravel the mixture of bark and sand did not attach to the claws causing lesions. When gravel was used, the natural rounded type was most suitable as cow track foundation.

The effect of pasture on milk production

Zero-grazed Danish cows produced 418 kg more milk (mean) than grazed Danish cows in a study made on herds with > 100 cows (Burow *et al.* 2011). In a British study (Haskell *et al.,* 2006) zero-grazed cows tended to have a higher milk production than grazed. In contrast, Herlin (1994) found no difference on milk production in a Swedish study comparing zero-grazing and grazing cows during or after the grazing season. In yet another Swedish study, Andersson (2012) found that that cows on production pasture had higher milk production then cows on exercise pasture.

Influence of housing system on claw health and hygiene

More than 50 % of Swedish dairy cows are kept in cubicle housing systems (Svensk Mjölk, 2011a). Since 2007, all new built dairy barns must allow the cows to be loose housed according to the Swedish animal welfare legislation. When changing from tie-stalls to cubicle systems the incidence of veterinary treated foot- and leg disorders increased dramatically for the first six months up to one and a half year after changing housing system (Hultgren, 2002). After 18 months, the incidence had slightly decreased compared to before the move. Manske (2002) found that cows in cubicle housing systems had a three times higher risk of dermatitis and heel horn erosion than tied cows in short-stalls and that the severity impaired with time since grazing. Multiparous cows with dirty claws had a higher risk of sole ulcer, white line fissure and double sole. A Norwegian study found large differences in claw lesions between housing systems where the prevalence was 48 % in tie stalls and 72 % in cubicles (Sogstad *et al.* 2005).

Cow comfort on floors

Flooring in cubicle housing systems needs to be durable, comfortable and provide good claw and leg health. It should have the right friction to avoid accidents and to assure that the wear on the claw is not too much or too little. The floors must also be easy to clean, dry and hygienic.

Concrete flooring, solid or slatted, is the most common solution in cubicle housing systems. Concrete flooring can be made less slippery if grooved. It can also be stamped with for example hexagon patterns. Asphalt flooring, mastic asphalt, is non-slippery but may be too rough and abrasive. Rubber flooring can be applied both on solid and slatted concrete floors. Rubber slatted flooring in the rear of tie stalls was found to improve claw health compared to solid rubber floors, apparently because of improved hygienic conditions (Hultgren & Bergsten, 2001). First calving heifers on slatted rubber flooring had a lower prevalence of lameness, sole hemorrhages and sole ulcers compared to heifers on slatted concrete flooring, but heel horn erosion prevalence was higher on the rubber flooring (Bergsten, 2009). Vanegas *et al*. (2006) found no overall difference in claw lesion prevalence between rubber flooring and concrete flooring in a cubicle housing system, but cows on concrete had a higher prevalence of heel erosion than cows on rubber flooring.

Wear of the claw and friction coefficients on different flooring

The wear on claws increases in cubicle housing systems, especially with new concrete. The average net growth rate of the claws was 2.0 mm per month in a study by Manske *et al.* (2002). The study was made in 15 herds, 10 with slatted concrete and 5 with scraped solid concrete. Manske *et al*. also studied tied cows and found that the average net growth rate was 2.6 mm for tied cows on concrete and 3.4 mm for tied cows on rubber mats.

Asphalt flooring increased both wear and growth of the claws compared to slatted concrete flooring and rubber flooring in a study by Telezhenko *et al.* (2009). Rubber flooring decreased the wear of the claws compared to concrete flooring in the study by Vanegas *et al.* (2006).

Telezhenko *et al.* (2005) showed that rubber mats on concrete had the highest coefficient of friction and the smallest change in friction between contaminated and clean areas. Slatted concrete had a much lower friction but also smaller differences if the surface was contaminated. Mastic asphalt flooring had a rather high friction coefficient, but also a very high decrease of the friction was measured when contaminated with manure. Also Faull *et al.* (1996) found that smooth and slippery indoor walking surfaces increased the risk of lameness.

Cows preferred to walk and stand on slatted or solid rubber mats rather than slatted or solid concrete floors (Telezhenko *et al.*, 2007).

Cow comfort in cubicles

Lying areas for dairy cows should be clean, soft and dry. Cubicles must provide comfort when lying down and rising and be large enough for cows to lie comfortably and naturally. However, the cubicle should not be too large that the cow can lie diagonally or defecate in the cubicle (Irish & Martin, 1983).

Rubber mats and mattresses are commonly used in cubicles. Mats and mattresses need litter to absorb moisture and reduce abrasions. Straw, sawdust, wood shavings, sand, dried manure and peat are common used litter materials alone in a deep bed or a thinner layer on mats and mattresses. Herlin (1997) compared comfort mats with rubber mats and concrete floors and found that cows were spending more time lying in the cubicles with comfort mats compared to the other bedding materials, and that the preparation time for lying down was shorter.

In a study made by Wechsler *et al.* (2000) the behavior and leg injuries on dairy cows on different bedding was compared. The study examined if cubicles with soft rubber mattresses or cubicles with straw bedding (manure and straw) was the best bed foundation for dairy cows. The results showed that the laying behavior of cows in both systems were similar to each other. However, leg injuries were more frequently found on cows in systems that used different types of soft mattresses than on deep straw.

Peat has a great absorption capacity and may even absorb airborne ammonia. Hock lesions decreased when using peat compared to deep straw. The cows where cleaner and cow comfort was better when using peat (Andersson, 2007).

Cows on sand beds had fewer tarsal lesions than cows on rubber-filled mattresses (Fulwider *et al.*, 2007). When using recycled sand with larger particles it resulted in a higher frequency of carpal (front knee) lesions than when using new sand. Fine-grained sand gave fewer hairless knees and lesions. Sand from the beds that spreads to the alleys makes them less slippery for the cows to walk on, which is beneficial (Rodenburg, 2000). Norring *et al.* (2008) found that the claw health and the cleanliness of cows were better on sand then on straw.

Lying behavior and time budgets in the stall and on pasture

The lying time varies between cows. Factors that have an effect on this are for example housing system, type of bedding used (Haley *et al.*, 2000) and softness of the bed (Tucker *et al.*, 2003). Cows at pasture lay down for longer periods than housed cows (Singh *et al.* 1993). In a study by Cook (2009) cows in cubicle housing systems spent around 11.3 hours per day lying down, see Figure 1

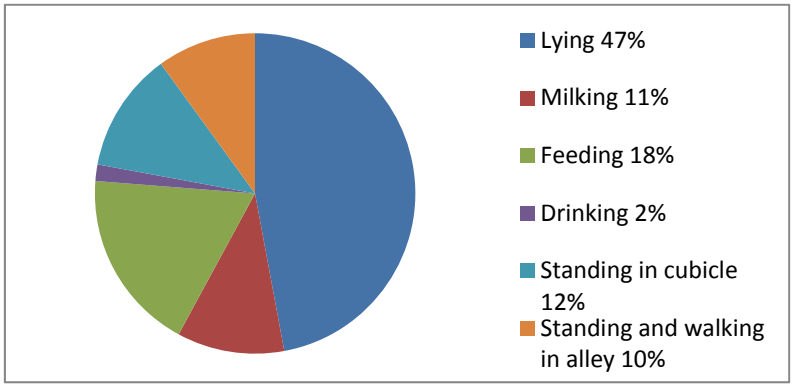

Figure 1 *Time budget (24hours) for cows in cubicle housing systems according to Cook, 2009.*

Cows preferred to be on pasture during the night and they preferred to spend their lying time on pasture according to a study made by Legrand *et al*. (2009). Cows spent on average 13 hours at pasture and preferred to be indoors during daytime.

Cow traffic- cows on pasture in AMS-systems

Cow traffic is an important aspect when planning pasture for dairy cows milked in AMS-systems since the cows need to be able to access pasture on their own. Cows in AMS systems were studied at pasture by Ketelaar-de Lauwere (1999). It was found that cows with unrestricted grazing had around 2.3 milkings per day, compared to zero grazed cows or cows with restricted grazing up to 12 hours per day, which had 2.5-2.8 milkings per day (Figure 2). The distance to pasture affected time at pasture, number of milkings and milk production (Wredle *et al*. 2002). Cows in an AMS system that were grazed near the barn (50m) spent more time at pasture compared to cows that grazed further away (260m). Both groups were also fed indoors.

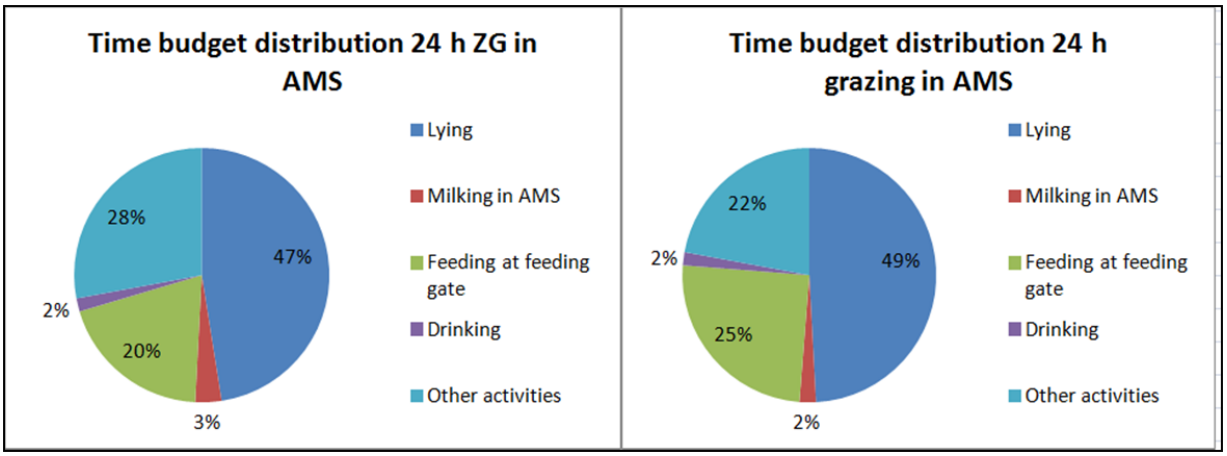

Figure 2 *Time budgets for cows in AMS systems, Zero-grazing vs. full-time grazing, Ketelaar-de Lauwere (1999)*

MATERIAL AND METHODS

This master thesis includes two studies. The first one was a pilot study on four Swedish conventional dairy herds, originally intended to study the effects of a divided grazing season and the effects of different amount of time at pasture on claw health and hygiene. The second study was a part of a questionnaire study made by the Swedish University of Agriculture (SLU) and the Swedish Dairy Association (SDA) granted by the SJV.

Robot herd study

The four herds were situated in different parts of Sweden, but all in the region where 3 months of pasture was dictated. All farms had AMS with at least two robots. One farm had a smart gate recording time at pasture for each cow. All herds had both Swedish Red and Swedish Holstein cows. The pasture management of the four participating farms is presented in Table 2.

Farmers were asked to fill in a "Pasture diary" and to note when cows were on pasture and interruptions in grazing, both for individual cows and for the whole herd. As this did not work out as was agreed upon, only one of the farms (number 2) with 4 robots could be analyzed statistically for total time on pasture for each cow and its effect on claw health. Farms number 1 and 4 were only analyzed for hygiene and farm number 3 was analyzed group wise without exact figures for how long time each individual cow had been grazed and when.

Table 2 *Type of grazing at the four studied dairy farms*

Farm	Type of grazing	Cows hygiene scored	Total number of cows
1	*2 of 3 robot groups had the opportunity to graze according to the Swedish legislation concerning pasture. The third group grazed from the middle of August, after claw trimming. All dry cows, due to calve between May 1st and October 30th, were grazed before calving.*	65	195
2	*2 of 4 robot groups were grazed 6 hours/day during a period of maximum 71 days during the grazing season. The number of days at pasture was scored for the majority of cows. All dry cows were grazed during the grazing season.*	117	309
3	*2 of 4 robot groups were grazed 6 hours per day during 3 months. The other 2 groups were grazed during the dry period if this occurred between April 1st and December 1st and if not reaching the prescribed period, they were on pasture before or after the common pasture period to complete their 3 months.*	149	238

4	*Farm number 4 had just one group of cows (one robot) but recorded their exact time outdoors with a smart gate. These cows were also divided into two groups for another trial; one group (25 cows) had access to production pasture and one group (31 cows) had access to an outdoor exercise area (1 hectare).*	51	56

The farms were visited two times. The first visit was made during the later part of summer when the grazed cows had been on pasture the whole summer, and not too long before housing. Hygiene scores for minimum 25 % of the cows were recorded by one person for cows both in indoor- and outdoor groups. On farm 4, almost all cows were hygiene scored. The second time the farms were visited was after pasture season in November to record hygiene scores again.

Hygiene scoring

The hygiene scoring system used was devised by Cook (2002) and divided the body in udder, lower and upper leg and flank. Each zone was scored from 1-4, 1 meaning clean, little or no evidence of manure; 2 = clean, only slight manure splashing; 3= dirty, distinct demarcated plaques of manure; and 4= filthy, confluent plaques of manure. For example pictures see appendix. After scoring 25% of the cows in a herd, the proportion of score 3 and 4 was calculated.

It was also noted if the cows had hocks with hairlessness, swelling or ulceration. Cows were scored with 0 if no injuries; 1 if hairlessness on one hook; and 2 if hairlessness on both hooks. Swelling and ulceration were noted if seen but not evaluated in the results.

Table 3 *Total number of hygiene scored cows*

	Indoor	On pasture
Summer	214	168
Winter	187	300

Stall environment

Stall environment was recorded (rubber mats in cubicles, alleys, and at the feeding table; slatted or solid flooring; kind of litter/mattresses in cubicles) and at the first visit, passage ways to the pasture were studied - bottlenecks, foundation, length (table 2).

Table 4 *Brief description of stall environment on the four dairy farms participating in the study*

Farm	Stall environment	Flooring alleys	Flooring at feeding table	Cubicles	Litter	Length of passage way
1	*Cubicle system with 3 robots. Slatted concrete flooring for housed cows. Scraped solid concrete flooring with hexagon pattern for pasture groups. Passageways: untreated soil (muddy)*	Slatted/solid concrete	Rubber	Rubber mat	Wood shavings	75 m
2	*Newly built cubicle system with 4 robots. Cleanmatic® manure system. Footbath with copper sulphate every other week. Passageways half concrete, "geo textile", stone meal and sand*	Rubber	Rubber	Mattress 30 mm+ 6mm	Wood shavings	50 m
3	*Cubicle system with 4 robots, ten years old. Feed stalls with rubber mats. Foot bath once per week (copper sulphate). Entrance concrete covered with a roof. Passage ways (an area as wide as barn connecting to the concrete platform) sloped with gravel and stone meal on top, needs refilling.*	Mastic asphalt	Rubber (feed stalls)	Water beds/mattresses	Peat mix	5 m
4	*Older cubicle system with 1 robot. Scraped solid concrete flooring. Passageways: soil*	Solid concrete	Solid concrete	Rubber mats	Wood shavings	50-150 m

Groups and claw trimming at Farm 2

Claw trimming was performed February 9th (221 cows) and during the pasture season July 4th (208 cows) 2011.

Table 5 shows the number of trimmed cows divided in groups with different access to pasture.

Table 5 *Number of cows claw trimmed at July 4th divided in groups with different access to pasture at the time of claw trimming. Groups are categorized according to the status at 2011-07-04, pregnant heifers are not included*

Number of cows trimmed in each group 110704	Number of cows	Percent
Dry cow grazing	12	5.8
Dry cow grazing + grazing	4	1.9
Grazing	98	47.1
Zero grazing	94	45.2
Total	208	100

Days in milk (DIM, Table 6) and parity (Table 7) was also recorded for all groups at farm 2

Table 6 *Days in milk for the different grazing groups at farm 2*

DIM for different groups 110704	Number of cows	10p	Median	90 p
Dry cow grazing	12	6	12,5	30
Dry cow grazing + grazing	4	10	16	421
Grazing	98	41	162	334
Zero grazing	94	107	212	424

Table 7 *Parity of cows in different grazing groups at farm 2. Information is missing for one cow in the grazing group.*

Parity	**Dry cow grazing**	**Dry cow grazing+ grazing**	**Grazing**	**Zero grazing**	**Total**
1	0	0	48	19	67
2	3	1	28	34	66
3	8	3	18	30	59
4	0	0	2	7	9
5	0	0	0	4	4
6	1	0	1	0	2
Total	12	4	97	94	207

Claw health records

Claw health was recorded by the claw trimmers at the four farms (four different claw trimmers) according to the "Klövhälsorapport" (Figure 19, Appendix). For each cow remark(s), type of lesion and its severity (mild, severe) was noted for dermatitis and digital dermatitis, heel horn erosion, haemorrhage, sole/toe/white line ulcer (each foot), and lameness. Claw conformation and other claw lesions were also diagnosed but without severity scoring.

Questionnaire Study

Telephone interviews

Two-hundred farmers were interviewed regarding stall environment and pasture management. A total of 269 Swedish dairy farms with loose housing systems and where at least 80% of the cows in the herd were trimmed both during spring and autumn 2010 were identified. In total, 16 401 cows were included in the study at the spring claw trimming and 17 635 cows at the autumn claw trimming. Spring trimming had to be performed between January 1st and 15 days after let out on pasture, and autumn trimming had to be 16 to 60 days after housing. The herds were classified as Swedish Holstein (at least 80% SH of the herd), Swedish Red (at least 80% SR of the herd), mixed SR*SH (both SH and SR were represented to a larger extent than other breeds), and other breed. The telephone interviews were made by three different persons.

Eleven of the interviewed dairy producers had no information on the length of the grazing period on their farm and were therefore excluded from the study.

The interviewed persons were asked to describe the stall environment with questions about flooring both in the alleys and along the feeding table, the cubicle bedding and litter, and the type of milking system. They were also asked about the grazing period- length in days and daily access in hours, type of grazing system, water supply, pathways and if they had any acute claw health problems. In the end of the interview they were asked if their opinion was that the pasture husbandry at their farm worked satisfying. The complete list of interview questions is included in the Appendix.

Results from the interviews were statistically analyzed together with claw health records from the claw trimmers as described in “Klövhälsorapport” above and in the Appendix. The prevalence of total remarks, dermatitis, digital dermatitis, heel horn erosion and sole ulcer was estimated in total and divided per different herd types/different pasture management according to the answers in the questionnaire.

Statistics

The results from both studies where analyzed statistically using Stata/SE 8.0. Prevalences for dermatitis, digital dermatitis, heel horn erosion, sole hemorrhages and sole ulcers were estimated in total and divided by herd factors (e.g. Herd breed, herd size). Non-overlapping 95% confidence intervals (CI) were used as indicating statistically significant differences between groups.

RESULTS

Robot herd study

Hygiene scores on pasture and indoors

Hygiene scores from all four farms were analyzed together independent on time on pasture. The prevalence of hygiene score 3 or 4 in the summer (July to September) of 168 cows that had been grazed and 214 cows that remained housed is shown in Figure 3. Grazed cows were cleaner on upper leg and flank ($P<0.05$). The hock lesion prevalence was lower in cows on pasture (51%) and than in housed cows (65%) but not significant (Figure 3). The results from the hygiene and hock lesion scoring in November including 300 previously grazed and 187 either partly or zero-grazed cows are shown in Figure 4. The differences were smaller and no significant differences between the groups were found.

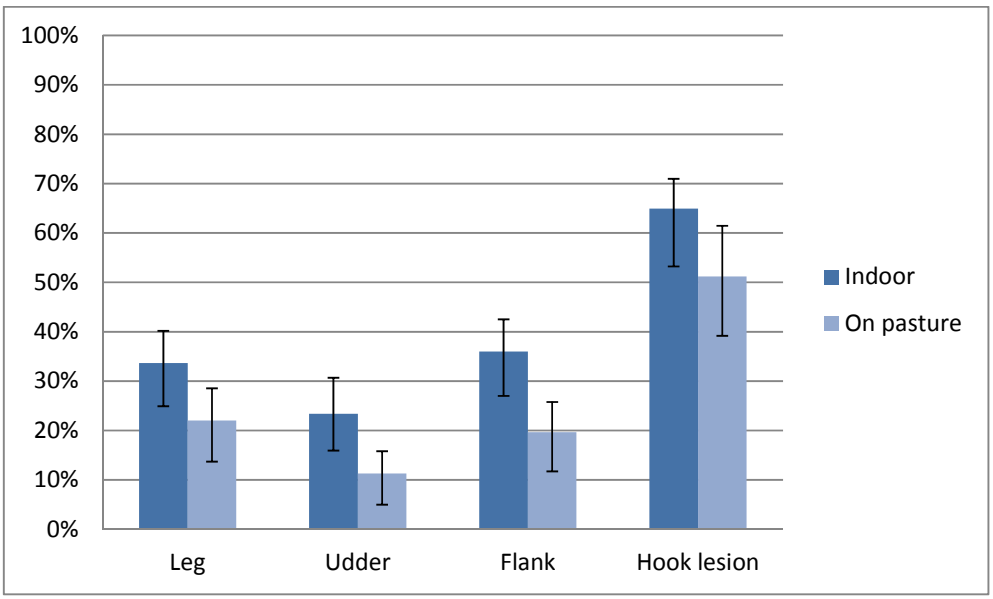

Figure 3 *Prevalence of hygiene score 3 and 4 during pasture season on leg, udder and flank and of hock lesions in any leg in cows kept at pasture for 41-113 days, mean =71 (n=168) or 0 days (n=214). Confidence interval 95%.*

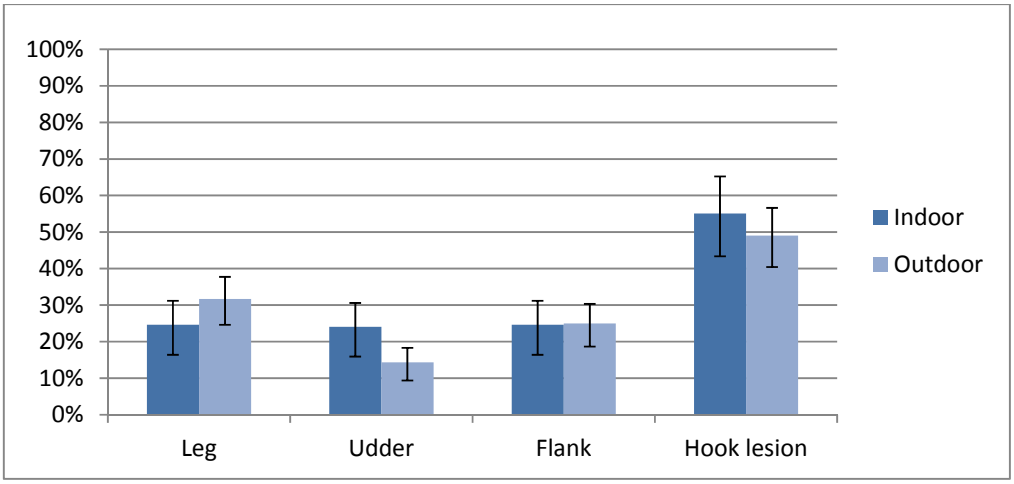

Figure 4 *Prevalence of hygiene score 3 and 4 during housing season on leg, udder and flank and of hock lesions in any leg in cows kept at pasture according to the Swedish legislation during the summer (n=187) or partly/zero grazed 0 days (n=300). Confidence interval 95%.*

Claw health on pasture and indoors

Claw data was only received from 2 farms which are presented in the following.

Farm 2

Figure 5 shows the total number of remarks at claw trimming in July. There was a numerical difference in total claw health remarks between cows grazed (42.2%) and zero-grazed (60%) but it was not significant. Neither the lower prevalence of heel horn erosion (Figure 6) in the grazing group compared to the zero-grazing group (52 % and 28 %, respectively) was significant.

The prevalence of dermatitis, sole ulcer and sole hemorrhages was low both in February (not shown) and in July as shown in Figure 7, Figure 8 and Figure 9.

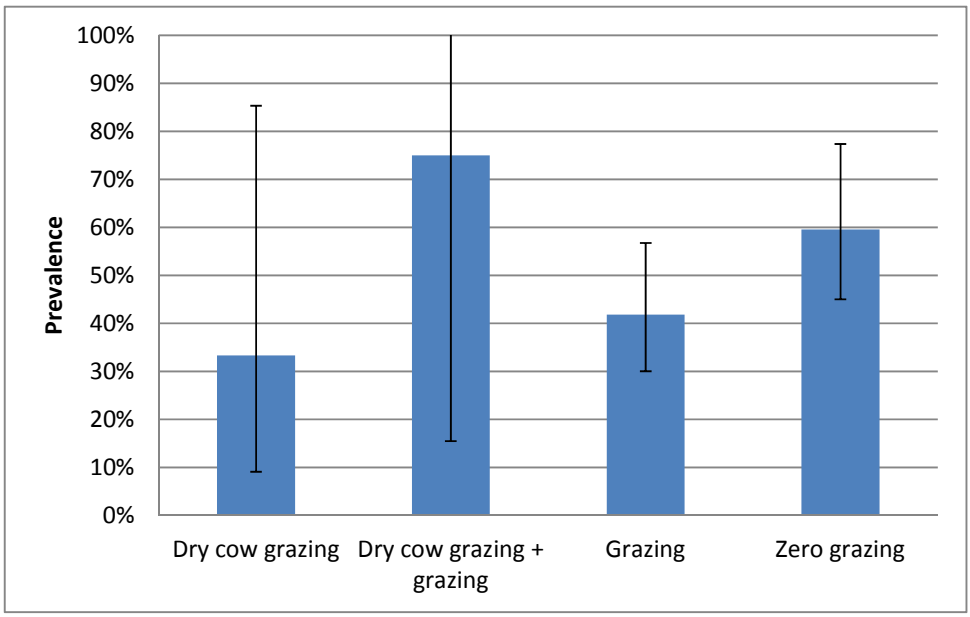

Figure 5 *Prevalence of total remarks in all pasture groups (dry cow grazing n= 12, dry cow grazing + grazing n=4, grazing n=98, zero grazing n= 94) at farm 2 at claw trimming 2011-07-04.Confidence interval 95%.*

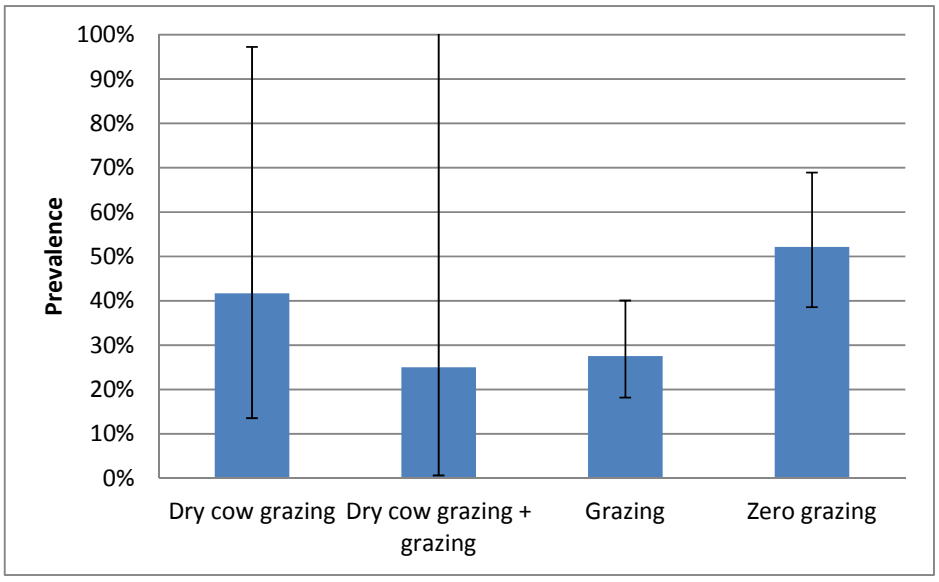

Figure 6 *Prevalence of heel horn erosion in all pasture groups (dry cow grazing n= 12, dry cow grazing + grazing n=4, grazing n=98, zero grazing n= 94) at farm 2 at claw trimming 110704. Confidence interval 95%.*

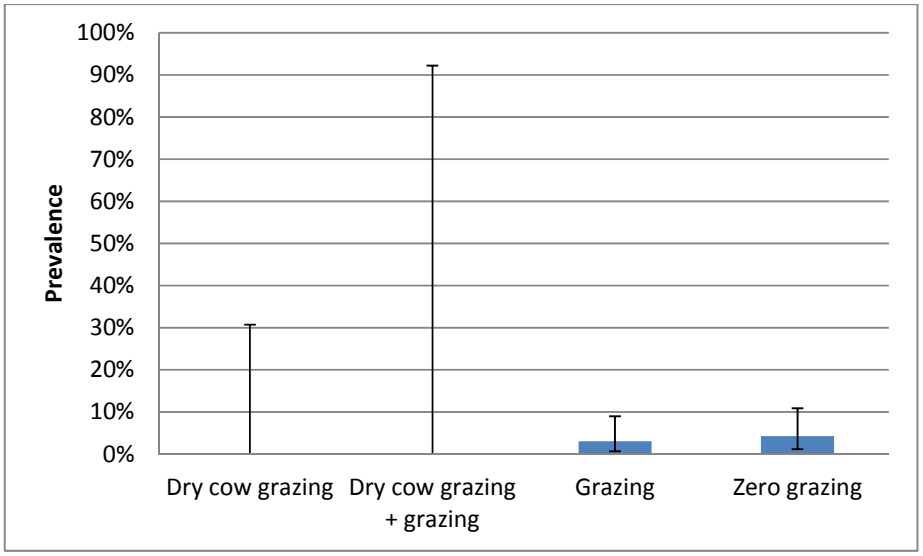

Figure 7 *Prevalence of dermatitis in all pasture groups (dry cow grazing n= 12, dry cow grazing + grazing n=4, grazing n=98, zero grazing n= 94) at farm 2 at claw trimming 110704. Confidence interval 95%.*

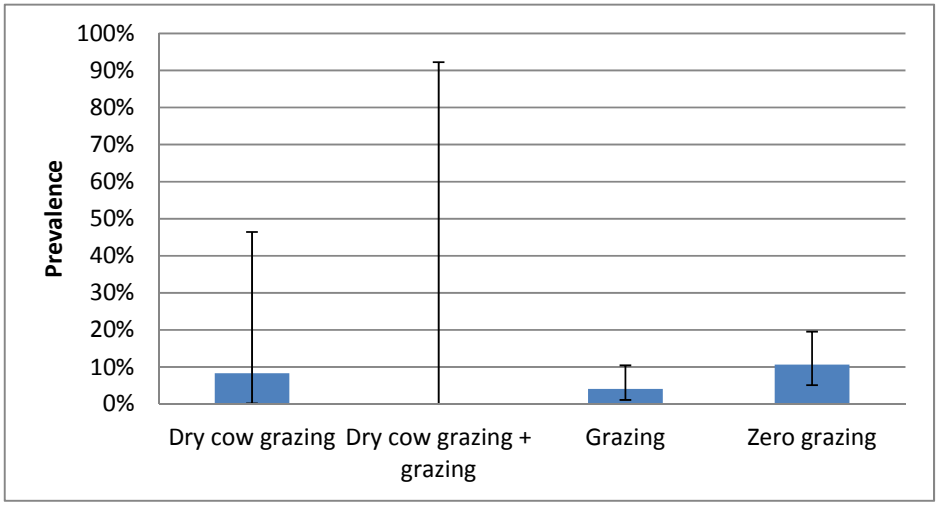

Figure 8 *Prevalence of sole ulcer in all pasture groups (dry cow grazing n= 12, dry cow grazing + grazing n=4, grazing n=98, zero grazing n= 94) at farm 2 at claw trimming 11070. Confidence interval 95%.*

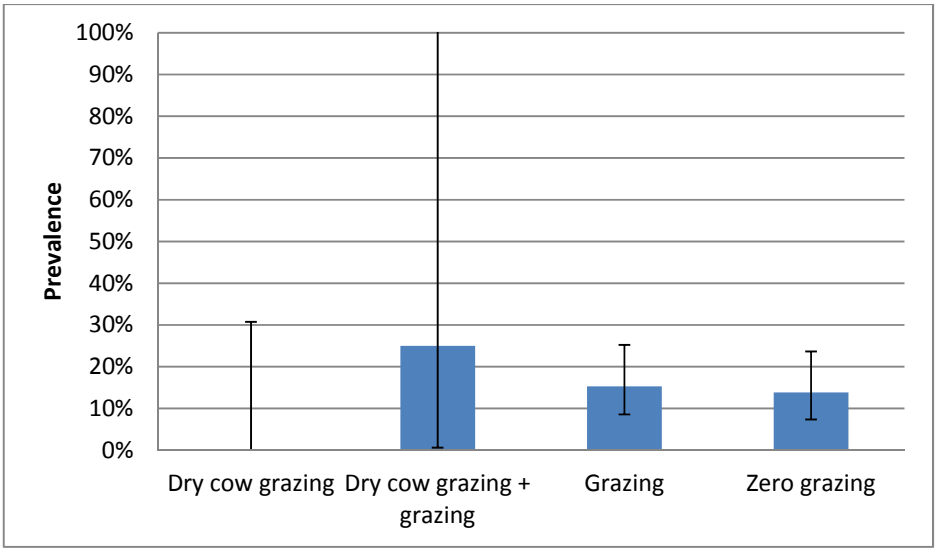

Figure 9 *Prevalence of sole haemorrhages in all pasture groups (dry cow grazing n= 12, dry cow grazing + grazing n=4, grazing n=98, zero grazing n= 94) at farm 2 at claw trimming 11070. Confidence interval 95%.*

Farm 3

Claw trimming was performed at four occasions during the spring and at one occasion late in the autumn (November 30th). Groups were, as described earlier, grazed continuously during the summer or grazing as dry cows+ additional grazing in the end of the grazing season to reach the dictated 3 months.

The prevalence of claw disorders at claw trimming on a total of 295 cows in November is presented in Figure 10. The prevalence of heel horn erosion was more than twice as high in the group that did not graze continuously (P≤ 0.05). There were no other significant differences between the groups.

A prevalence of 9.5% sole ulcers (28 cows with sole ulcers on one or several claws in 295 cows) was treated in the herd at autumn trimming, (not in figure) but no difference in the prevalence of sole ulcer between cows with flexible or continuous grazing was found. There were no lame cows recorded by the claw trimmer in the herd at the time of claw trimming.

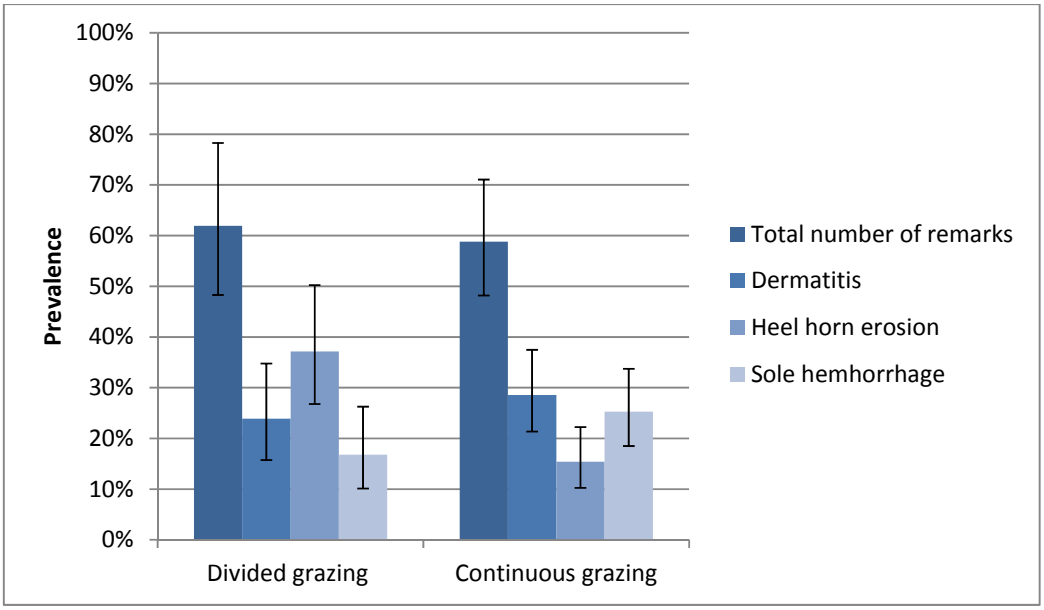

Figure 10 *Prevalence of claw disorders at autumn claw trimming, November 30th, on farm 3 divided in groups with different grazing strategy. Confidence interval 95%.*

Questionnaire study

Prevalence of claw health remarks depending on different factors

Many factors did influence the prevalence of claw health remarks, both at spring trimming and at autumn trimming. Some of them are presented in the following and the rest can be found in the appendix. The practiced grazing time is shown in Table 8 , and there was a variation, with less and more time grazing, in relation to the dictated grazing time.

The prevalence of claw health remarks varied between grazing zones. The prevalence of total number of remarks at autumn trimming was significantly ($P<0.05$) higher in zone 2 compared to zone 1, and zone 3 had a higher prevalence than both zone 1 and 2 (Figure 11).

There was a consistent difference in the prevalence of claw health remarks between Swedish Holstein and Swedish Red herds, Figure 12. In the spring, SR had a significantly higher prevalence of total remarks ($p\leq0.05$) and heel horn erosion ($P\leq0.05$) than SH herds, but after the grazing season there was no significant difference. SH herds had higher prevalence of dermatitis ($P\leq0.05$) and sole ulcers ($p\leq0.05$) at autumn trimming compared to SR herds.

Before grazing in spring there was no difference between production system (organic or conventional, Figure 13), but after grazing in autumn, organic cows had a significantly lower prevalence of claw health remarks than conventional cows ($P\leq0.05$). The prevalence of dermatitis and digital dermatitis was also significantly lower in organic cows ($P\leq0.05$). Heel horn erosion on the other hand had a higher prevalence in organic cows ($P\leq0.05$).

Total number of remarks at autumn trimming was 65 % higher in the smallest herds compared to herds with more than 200 cows (Figure 14) and the difference was even larger in spring. There was no difference at all in claw health remarks at spring trimming compared to autumn trimming in herds with 200 cows or more. Heel horn erosion was much more prevalent (P≤0.05) in herds with less than 50 cows; other herd sizes did not differ that much although there was a significant difference (P≤0.05) also between herds with 50-199 cows and 200 cows or more. Dermatitis and digital dermatitis was less prevalent (P≤0.05) in small herds than in larger before the grazing season and more prevalent after housing.

No larger differences in claw health between milking systems was found (Figure 23 in the appendix). There was a slightly higher prevalence of dermatitis (P≤0.05) in AMS herds than in herds with milking parlours. The six herds with rotary milking parlours had a lower prevalence (P≤0.05) of total remarks both at spring trimming and autumn trimming. Those also had a higher prevalence of digital dermatitis at spring trimming but recovered after grazing and had a lower prevalence at autumn trimming (P≤0.05) compared to the other milking systems.

Pasture parameters

Cows that were 138 days or more on pasture had 64 % lower prevalence of claw health remarks at the autumn trimming than cows with less than 100 days on pasture (Figure 16). No clear trend was seen although long time at pasture resulted in lower and short time at pasture resulted in a higher prevalence of dermatitis. The risk of digital dermatitis and heel horn erosion were higher for cows that had a shorter grazing time. Cows grazing more than 138 days had lower prevalence (P≤0.05) of heel horn erosion compared to the other groups.

When calculating how many hours in total the cows spent on pasture during the whole grazing season there were no significant differences found in claw health (Figure 24 appendix).

Flooring parameters

The prevalence of claw health remarks was higher (P≤0.05) for all claw lesions in herds with solid concrete flooring compared to slatted concrete flooring (Figure 25). Both flooring groups recovered from heel horn erosion during the grazing season.

Herds that had rubber mats in the alleys had a higher prevalence (P≤0.05) of all different claw lesions at both trimmings except for sole ulcer at spring trimming (Figure 17). There was no large improvement in total number of claw health remarks depending on the treatment of the flooring (rubber mats, concrete or concrete with pattern) during the grazing season (Figure 28).

Table 8 *Practised grazing time (according to the questionnaire) for herds in different grazing zones1-3*

Zone	< 2 months	2-3 months	3-4 months	> 4 months	Total
Zone 1	0	0	4	27	31
Zone 2	1	3	27	64	95
Zone 3	1	12	27	10	50
Total	2	15	58	101	176

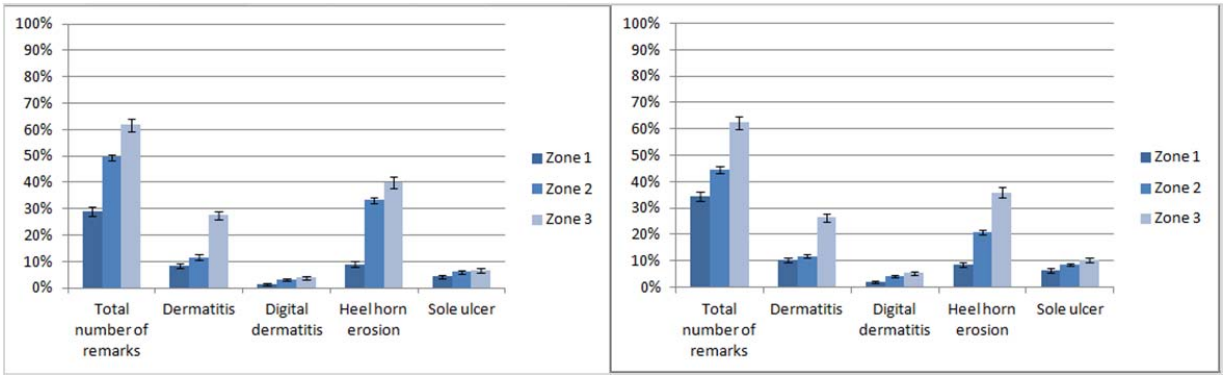

Figure 11 *Prevalence of claw health remarks depending on pasture zone 1-3. Spring trimming to the left and autumn trimming to the right. Zone 1=4 months pasture, zone 2=3 months pasture, zone 3=2 months pasture (minimum). Confidence interval 95%.*

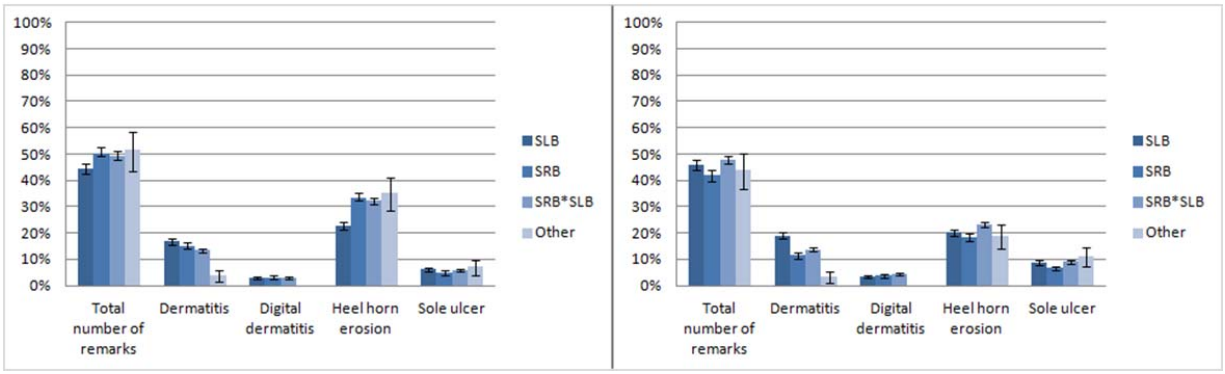

Figure 12 *Prevalence of claw health remarks related to breed (SH=Swedish Holstein, SRB=Swedish Red, SH*SRB, and other breeds). Spring trimming to the left and autumn trimming to the right. Confidence interval 95%.*

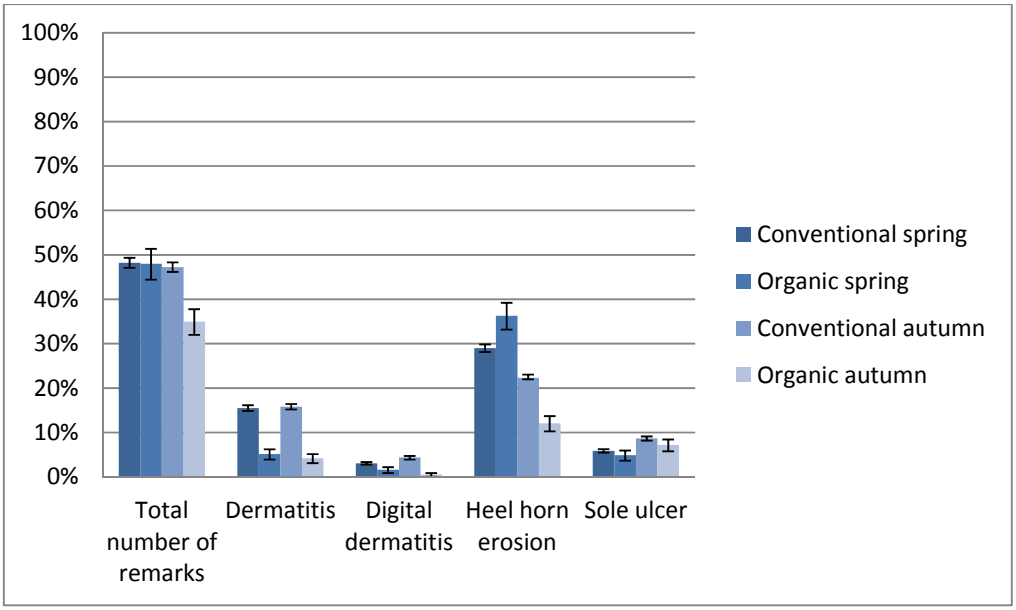

Figure 13 *Prevalence of claw health remarks in organic (N=23) and conventional (N=153) dairy production. Confidence interval 95%.*

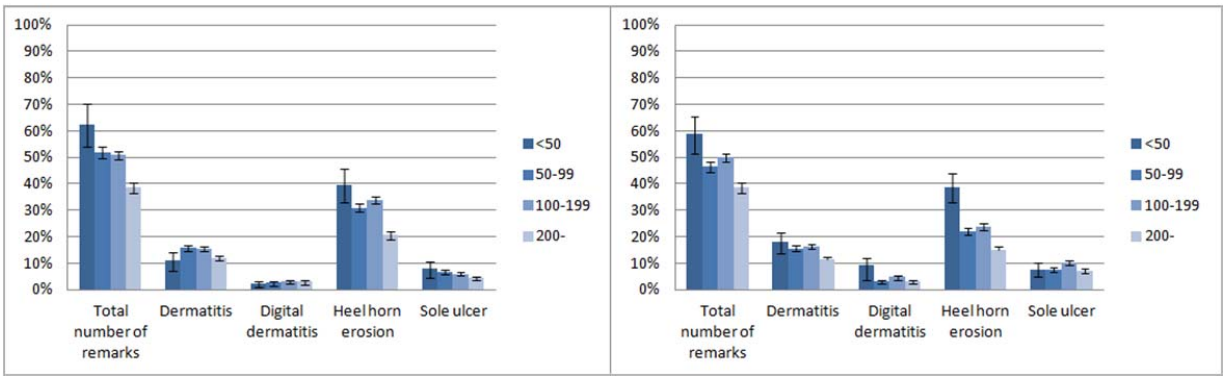

Figure 14 *Prevalence of claw health remarks related to herd size at spring trimming (left) and autumn trimming (right). Confidence interval 95%.*

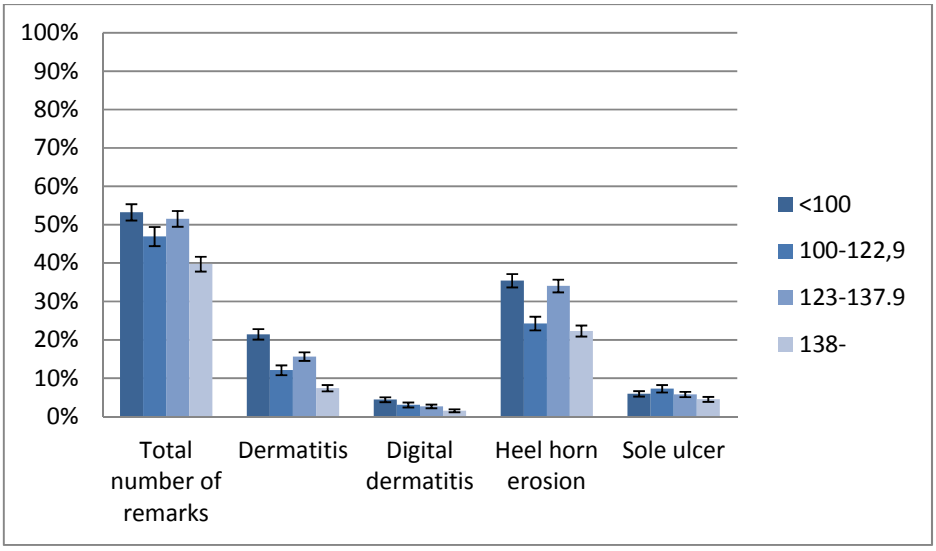

Figure 15 *Prevalence of claw heath remarks at spring trimming in herds with different number of days at pasture according the interview. Classes are divided into quartiles. Confidence interval 95%.*

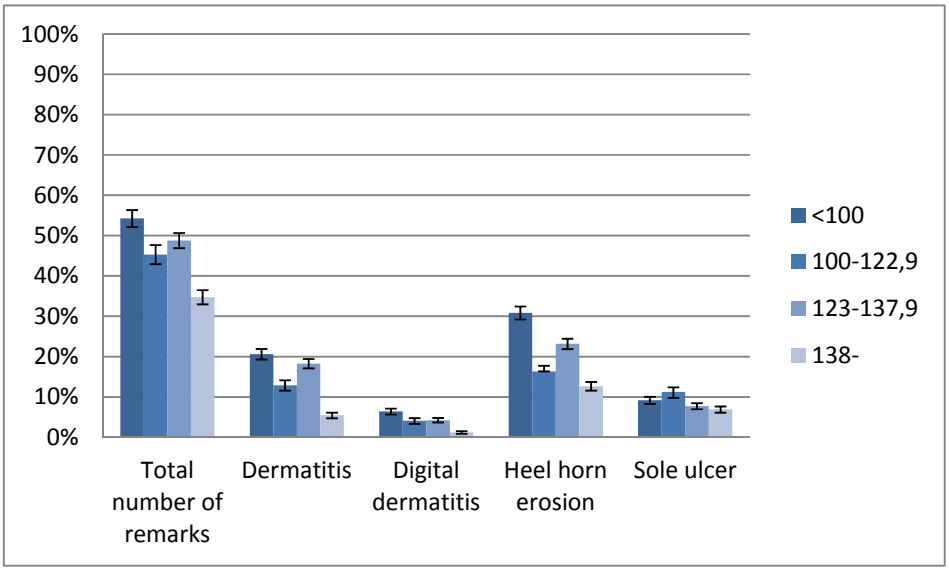

Figure 16 *Prevalence of claw heath remarks at autumn trimming related to days at pasture. Classes are divided into quartiles. Confidence interval 95%.*

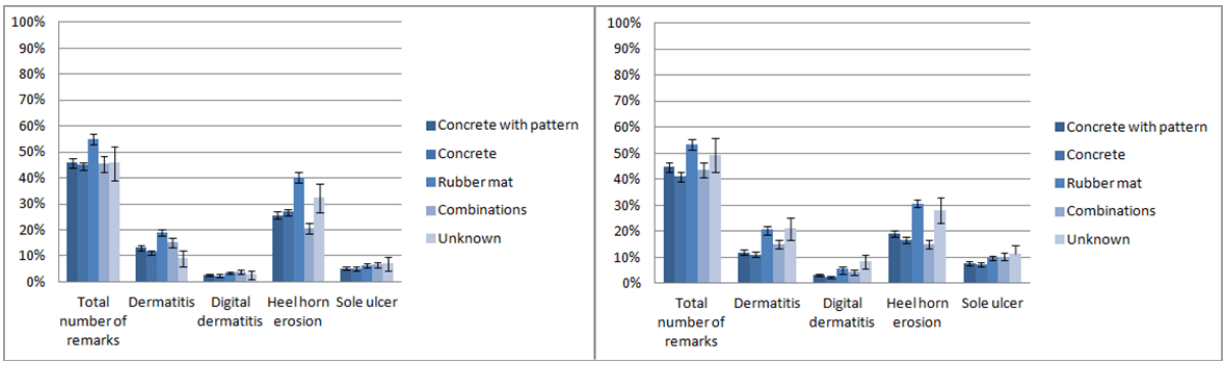

Figure 17 *Prevalence of claw health remarks at spring and autumn claw trimming related to alley flooring system. Confidence interval 95%.*

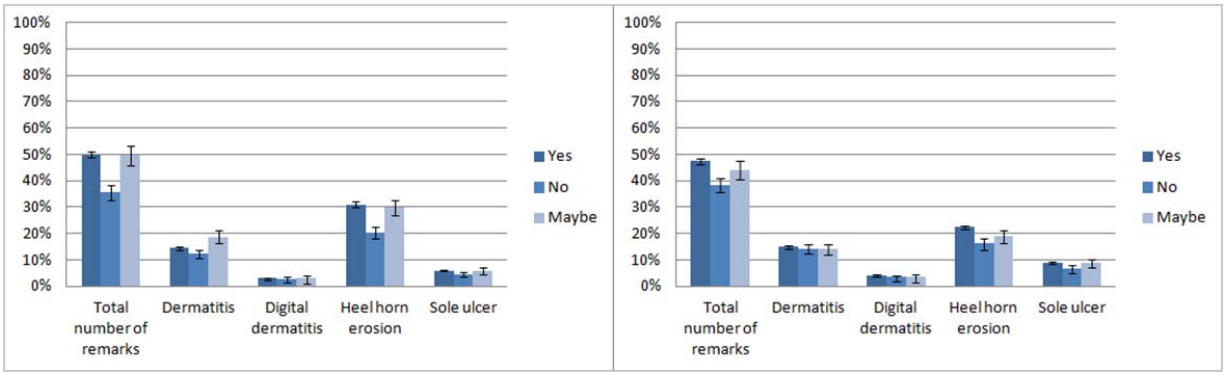

Figure 18 *Prevalence of claw health remarks at spring and autumn claw trimming related to the farmers attitude to pasture husbandry. Yes= pasture worked satisfactory, No= pasture did not work satisfactory. Confidence interval 95%.*

Telephone interviews - summary of the comments of the famers attitude

As many as 79% answered "yes" on the question "Do you think that the pasture husbandry works satisfying in your dairy herd?", 11% did not feel that pasture worked satisfying and 12% were unsure or thought it depended on the point of view (Table 27). Farmers who answered the question "Do you think that the pasture husbandry works satisfying in your dairy herd?" with "no", had cows with a lower prevalence of all claw health remarks at spring trimming and also after the pasture season at autumn claw trimming (Figure 18).

Grazing perspectives

Several of the interviewed persons thought that flexible pasture regulations would help, for example the ability to keep the cows inside due to rainy weather. Some also mentioned that it would be beneficial to have the opportunity to keep high yielding cows housed during the middle of the summer.

Positive and negative pasture factors were mentioned. Those who referred to the benefits of grazing often stated that grazing improved animal health, claw- and leg health and the cows were more comfortable out on pasture. Many farmers kept the doors open and let the cows choose whether they

preferred to be outside or indoors. Approximately 9% of the interviewed farmers said it was much more work managing cows on pasture, some thought not. Things that were considered time consuming were maintaining fences and passageways, trimming of pasture, moving cows etc. Positive factors were saving bedding material, less labor cleaning stalls and alleys and possibility to do things in the barn when the cows were outside, such as cleansing and reparations.

Grazing in robot systems

Comments on milking robots and grazing - the proportion who thought that the robot system worked satisfying or even better during the pasture season was larger than the proportion who said they had problems. Fewer milkings and less good cow traffic in robotic systems were mentioned as problems by some. Several stated, that in order for the robot system to work satisfactory cows must be given the same amount of feed indoors also during the summer, which interfered with grazing.

Effects on production

Some of the interviewed stated that they succeed with grazing without loss of production. Problems with feeding and failure to give the cows enough energy-rich feed was mentioned by 6%. Nine percent stated that milk production decreased in grazed cows. Some believed that pasture was bad for the economy, while others thought that the loss in production was compensated by better animal health, less work, or less feed consumption indoors.

Problems with grazing

Rain, causing trampled and muddy drive and passage ways, was the most common reason for keeping cows from pasture. Nearly 70% of the respondents kept their cows indoors for some reason a few days every summer and 96% of these were because of rain. Dry and warm weather (5%) could also be a problem, but not as common as rain. Many said that cows didn´t want to go out when it was too warm; some had problems with sunburned udders or insects.

Other problems connected to pasture mentioned were increased somatic cell counts, pasture fever (tick born infection), coli mastitis especially if there were puddles outdoors. Some said claw infections (Interdigital phlegmon) increased if the weather was rainy; some had problems with pebbles in the claws. Some indicated that troubles with cow routines occurred and that it was difficult for the cows to walk out to pasture. There were also problems with wild animals reported such as wild boar and bear. Problems with logistics on the farm were also mentioned- pasture may complicate logistics if there is a need to drive with machinery or cars on or cross the passage ways.

Views on regulations

Some of the interviewed farmers thought that animal welfare inspectors should be harder while some thought that animal welfare inspectors should be more flexible and that the rules should be less bureaucratic. For example, the regulations of having heifers indoors for artificial insemination (AI) of up to 30 days, - then there was not time both for AI and pregnancy check. Someone thought that exercise pens cannot be called or compared to pasture. Some said they had cows on pasture just because it was the law and it would be better to allow zero-grazing in conventional herds and letting consumers choose if they are prepared to pay extra for organic milk where cows are on pasture summertime.

DISCUSSION

Studies of dairy cows´ performance on pasture are made under different conditions. Cows in pasture based systems with little or no supplement of concentrates are not to be compared with high yielding cows in zero-grazing systems fed indoors. Also in Swedish cubicle systems, grazing is managed in different ways and different for different categories of animals in the herd, which has been studied in this work. The results from the present study came from direct observations, from farmer based records from the Swedish Dairy Association and from interviews. In the Robot herd study it was very difficult to recruit participating herds and it was not possible to change any routines for grazing or claw trimming. Thus the results are observations of the present situation. However, in the Questionnaire study, herds were strictly selected from those who had claw trimming records at the end and at the beginning of grazing season and which were members in the official milk recording scheme. There was also a higher number of participating cows in the Questionnaire study compared to the Robot herd study.

Hygiene and hock lesions in Robot herd study

Flank and upper leg hygiene was better for cows on pasture compared to those not yet grazed. No significant differences were found on legs and udders. Ellis et al. (2006) found cleaner cows on pasture compared to winter housed. However, this is not exactly comparable as cows kept indoors during summer had different environmental conditions, such as temperature and humidity, compared to winter housing.

It was not possible to compare the different beddings in the Robot herd study since the cows in the herds spent different time at pasture at different time periods. The cows at farm 3 had different bedding in the two groups (waterbeds and mattresses) but it is most likely that the grazing time itself was a larger source of differences in hygiene and hook health. Also, there was a lack of information on parity and lactation stage on farm 3, which might have influenced the results.

The tendency towards a lower prevalence of hook lesions in cows on pasture is in accordance with other studies. Rutherford *et al*. (2008) found that cows that were grazed had a lower prevalence of hairless hocks in autumn, after the grazing season, compared to spring. A study by Gustafson (1993) found that cows that were exercised had a lower risk of hock lesions. Those cows were tied and exercised during winter time and not comparable with loosed housed cows. There are studies on cow comfort in cubicles indicating more hock lesions when using synthetic mattresses compared to other bed alternatives (Fulwider *et al*. 2007, Wechsler *et al*. 2000). The prevalence of hock lesions in the grazed group with rubber mats in the cubicles at farm 3 compared to the indoor group on water beds could therefore have been influenced by a less good cow comfort on the rubber mats, even if these cows also had the opportunity to lay down on pasture, which is the most natural and comfortable bedding for cows.

The present study did not investigate the correlation between cleanliness and hock lesions but Zurbrigg et al. (2005) found that cows with poor hygiene were more likely to have hairless hocks and Manske (2002) found a higher risk of claw lesions in animals with dirty legs. Many claw lesions are increasing at poor hygienic conditions and environment (Bergsten and Pettersson, 1992; Collick, 1997; Manske, 2002), and as grazing improves cows' hygiene it should have positive effects on claw health.

Claw health in Robot study

The cows in the Robot herd study were trimmed according to routines at respective farm and no intervention was made. Thus the trimming times were not optimal in the study. At farm 2, the majority of cows were trimmed after only 38 days on pasture.No significant difference in claw health was found between grazed cows and those not yet grazed. The grazed group had fewer days in milk than the zero-grazed group. It is well known that production diseases are commonly occurring in the beginning of lactation and claw diseases are commonly detected from early to mid-lactation (Greenough *et al*., 1997). It is possible that studies on animals in comparable stages of lactation and with a larger group of animals would give other results and extended studies including the whole pasture season for both groups, and studies on a larger number of cows are needed. It would have been interesting to compare the groups after longer time on pasture to see if there was a real difference between groups and if so if it was a result of recovery of diseased cows on pasture or a deterioration of zero grazed. Olmos et al. (2009) found that grazed cows had better claw health from 85 days at pasture and lower lameness prevalence from 180 days post calving than zero-grazed cows. The dry cow groups at farm 2 were too small and no conclusions could be made from their claw health results. Furthermore, dry cows at pasture were less likely trimmed in the middle of the summer which means that the selection of cows for trimming in July could have biased the results.

Cows at Farm 2 had very dry alleys and a low prevalence of total claw health remarks and heel horn erosion in February compared to July which was surprising. Also at farm 3; heel horn erosion prevalence was very low in spring compared to autumn trimming. These results were in contrast to the study by Andersson & Lundström (1981) where the highest prevalence of all claw diseases from slaughtered cows was found in spring. However, 90% of those cows were from tie stalls where the contrast from the stall environment to pasture might have been bigger than in present study where all cows were cubicle housed. Grazing in tie stalls previously was usually day and night while it is more common today in cubicles that the cows are grazed either night or day and therefore the seasonal contrast is less. There might also have been an effect of claw trimmer, although claw trimmings at both farm 2 and 3 was made by the same trimmer both times. Anyhow, there was a higher prevalence of heel horn erosion in the zero-grazing group (NS) and the group with divided grazing ($p \leq 0.05$) compared to the grazing groups at trimming after housing.

Autumn claw trimming at farm 3 was made in November which, for some cows, was many months after housing and for others might have been approximately 1 month after housing. Since approximately 50% of the cows in this herd had a flexible grazing period or only dry cow pasture between April and December, many of these were claw trimmed several months after housing. This was not the case with the summer grazing cows, which all were housed at October 1st. These differences in trimming date in relation to pasture make it difficult to compare the groups. The lasting effect of the treatments would have to be evaluated through trimming in the spring.

Questionnaire study

The design of the Questionnaire study was made to identify differences in claw health related to the grazing management by selecting appropriate trimming dates before (spring trimming) and after grazing (autumn trimming). There were rather large significant differences in claw health between the different

pasture regions, where cows with a minimum grazing of 2 months had a higher prevalence of claw health remarks compared to those regions aimed for a minimum of 3 or 4 months on pasture. The replies from the questionnaire showed that there was a large variation in practiced grazing time between regions but the result was still repeated. The cows in the northern regions were probably on pasture for a shorter period of time than cows in the southern region, but many herds in zone 3 grazed their cows for more than 3 months. Whether the results could be biased by regional differences in the way claw trimmers assessed the lesions is doubtful.

Interesting was that the number of days grazing had a much larger impact on claw health than the actual time spent grazing each day or the time with access to pasture each day. It is impossible to know how many hours per day that the cows in AMS-systems actually spent on pasture since they had free access and were not forced to go out. If pasture relieves the cow from being in a less good environment indoors it may be better to have shorter intervals of pasture relief over the year than a short and intensive seasonal pasture time.

Interesting was also that cows in organic production had the same prevalence of claw health remarks in spring as cows in conventional production. After grazing, at autumn trimming, claw health of organic cows improved considerably, but no change of the prevalence was seen in conventional cows. This may be an effect of the extended rules for keeping organic cows on pasture – 12.5 hours a day - compared to 6 hours for conventional cows. In addition, organic cows must receive 6 kg DM per day or more of their forage intake from pasture which means that their pasture was a real pasture and not only exercise in a green area. There might also be an effect from breed, as most organic farms in the study had SR cows, 10 of 23 farms compared to 2 farms with SH. When looking at the claw health remarks and breed, SR had a significantly higher prevalence of remarks in the spring than SH, but improved much during grazing. This finding is surprising as earlier Swedish studies consistently found SH to have most claw lesions (Andersson and Lundström, 1981; Manske, 2002). The difference in milk yield between conventional and organic cows should also be considered, but is not explaining the change in claw health during the grazing period.

There were no larger differences found in claw health between milking systems, except for herds with rotary milking, which had a lower prevalence for all claw lesions except for a higher prevalence of digital dermatitis in the spring. However, there were only six herds with rotary milking systems. Earlier reported differences in claw health have compared tie stalls with cubicle stalls and not the milking system within loose housed cows *per se*.

The differences in claw health, both before and after the grazing period, between small (less than 50 cows) and large herds (more than 200 cows) was rather large. In contrast to the smaller herds the largest ones had no significant difference in claw health before and after pasture: This may be an effect of stall environment- larger herds were perhaps more likely to have new built stalls. The average herd size is increasing every year in Sweden, and if expanding the herd size, the producers have to build new better housing facilities in most cases. Sogstad et al. (2005) found no negative effects on claw health related to larger herd size but in Norway, the herd size and the milk production (ECM per cow and year)

is lower than in Sweden. In contrast to present results Faye and Lescourret (1989) found that smaller herds had fewer problems with lameness.

There was a clear trend for dermatitis, digital dermatitis and heel horn erosion to decrease with longer time on pasture. This is in accordance with studies by Somers *et al*. (2005a, b) who found higher prevalence of DD, interdigital dermatitis and heel horn erosion in cows with restricted or zero-grazed cows.

When interviewed, dairy producers with AMS had different opinions concerning AMS and grazing. Some had no problems with cow traffic during the grazing period, and some stated that they had fewer milkings per day and cow during the grazing period. In the study made by Ketelaar-de Lauwere (1999), only 24 cows were used to investigate differences in number of visits to the AMS when zero-grazed, access to pasture for 12 hours a day or unrestricted. They found no major differences in visits to the AMS but since there were two milking stalls available, conditions may not be realistic. Normally there would be up to 75 cows in each robot, creating bottle necks at the most popular milking times in the day. Claw health is even more important when keeping dairy cows in an AMS system, since cows need to be able to walk voluntarily to the milking stall and will not be herded as in other loose housing systems.

The quality of passage ways was a complicated parameter. Passage ways were described in many ways in the telephone interviews and categorizing them was very hard. The difference of claw health with gravel or soil in passageways was not very large. Gravel was the most straightforward description of groundwork; others were hard to group as there were many different solutions. Soil is probably the description of a passageway which was not processed in any way, most likely to become dirty and slippery in rainy weather. Claw health remarks had a higher prevalence among cows walking on “soil”. Definition of quality of passage ways must be made more precisely to be beneficial to analyze.

Flooring

Cows kept on slatted flooring were shown to have a lower risk of claw lesions (except DD) at both spring and autumn trimming compared to those kept on scraped solid flooring. This was not surprising as heel horn erosion was the most common disease and is related to the humidity of floors (Bergsten and Pettersson, 1992). It is also in accordance with Hultgren and Bergsten (2001) although their study was made on tied dairy cows. It is more surprising that rubber mats in the alleys gave a significantly higher prevalence of all different claw lesions at spring trimming (and at autumn trimming) than concrete floors in present study. This is in contrast to the findings by Vanegas *et al*. (2006) who found little difference in claw health between cows on concrete and rubber flooring and Bergsten (2009) who found less lameness, and claw horn lesions in first calvers on slatted rubber flooring compared to slatted concrete. Bergsten (2009) on the other hand, found increased risks of heel horn erosion in first calvers on slatted rubber flooring probably because of less drainage area than on the compared concrete slats. Another explanation to less recorded heel horn erosion on concrete floors is more horn wear and thus a faster replacement of diseased heel horn than on rubber flooring. As heel horn erosion was the most frequent disease in “all different claw lesions” this could be a possible explanation of the result above.

Digital dermatitis increased during the grazing period in the smaller herds. Digital dermatitis is caused by bacteria and is associated with wet environmental conditions and exposure to slurry (Blowey 2008). Wet passage ways to pasture may be the explanation for this, although digital dermatitis is mostly seen in housed cows.

There was also an increased risk of heel horn erosion with shorter practiced grazing time but in the medium grazing groups the results were the opposite. This may be because of 50 % of the cows were grazing 100-138 days and most of these herds had a grazing time around 123 days. This means that dividing these in two groups was not rational. This was of course also the case with all other remarks.

Finally, it was very interesting that farmers that answered the question "Do you think that the pasture husbandry works satisfying in your dairy herd?" with "no" had better claw health in their herds than farmers that answered "yes". Either, this was because they had higher demands? Or, it was because there was no improvement in claw health during pasture for these herds. The farmers´ attitude to graze is very important for reliability of the unique Swedish welfare legislation.

CONCLUSIONS

Grazing time had a positive effect on dairy cows' hygiene, claw and leg health in most systems in both the Robot herd observational study and in the epidemiological Questionnaire study. However, there were many individual and herd related factors that influenced claw health more than the grazing *per se*. The effect of a flexible grazing period could not be evaluated in this study.

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APPENDIX

Table 9 *Claw health statistics for Sweden during the period 20100901-20110831 (Cows included in the Official Milk Recording Scheme (OMRS))*

Contributing herds	Average number of cows per herd	Contributing claw trimmers	Visits/ herd		
			1 time	2 times	3 times
2334	78	170	911	884	318

Trimmings/cow			Trimmed	
1 time	2 times	3 times	Heifers	Beef cattle
98037	67953	12670	3104	1581

REGISTRATIONS	Total	OK	%	Dermatitis	%	Digital Dermatitis	%
Primiparous cows	57527	35952	62,5	4495	7,8	1789	3,1
Multiparous cows	215810	116420	53,9	19980	9,3	6893	3,2
Total	273337	152372	55,7	24475	9	8682	3,2

	Heel horn erosion	%	Hemorrhage sole+ white line	%	Ulcer, sole+toe+ white line	%	White line abcess	%
Primiparous cows	8595	14,9	11076	19,3	3316	5,8	71	0,1
Multiparous cows	49431	22,9	42794	19,8	15875	7,4	547	0,3
Total	58026	21,2	53870	19,7	19191	7	618	0,2

	Sole+toe abcess	%	White line separation	%	Double sole	%	Verrucose dermatitis	%
Primiparous cows	31	0,1	847	1,5	505	0,9	104	0,2
Multiparous cows	191	0,1	6839	3,2	4537	2,1	491	0,2
Total	222	0,1	7686	2,8	5042	1,8	595	0,2

	Interdigital hyperplasia	%	Interdigital phlegmon	%	Lameness	%	Leg injury	%
Primiparous cows	1047	1,8	174	0,3	223	0,4	202	0,4
Multiparous cows	10307	4,8	289	0,1	1423	0,7	944	0,4
Total	11354	4,2	463	0,2	1646	0,6	1146	0,4

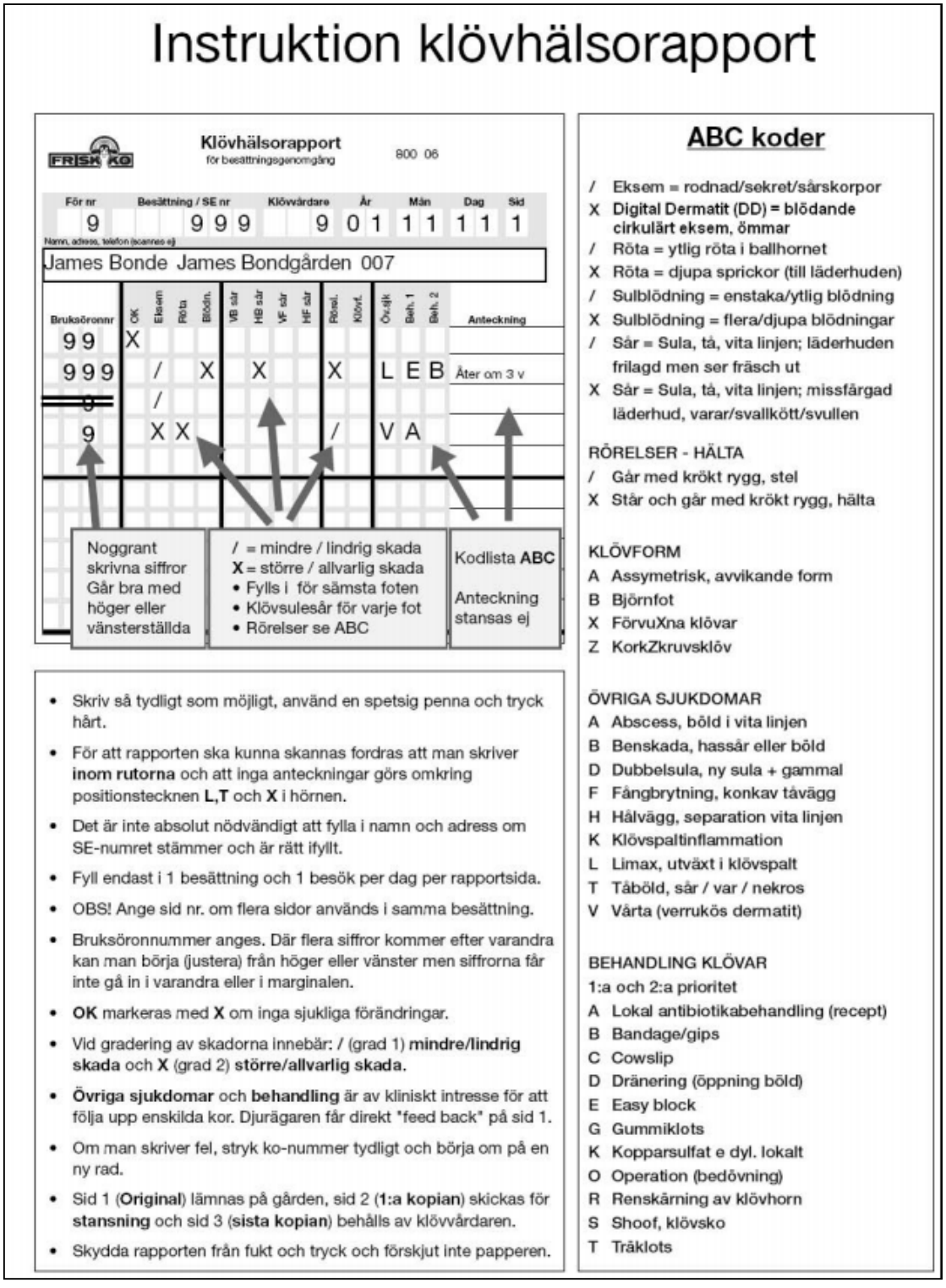


Figure 19 *Claw health report (Klövhälsorapport) used by claw trimmers in Sweden.*

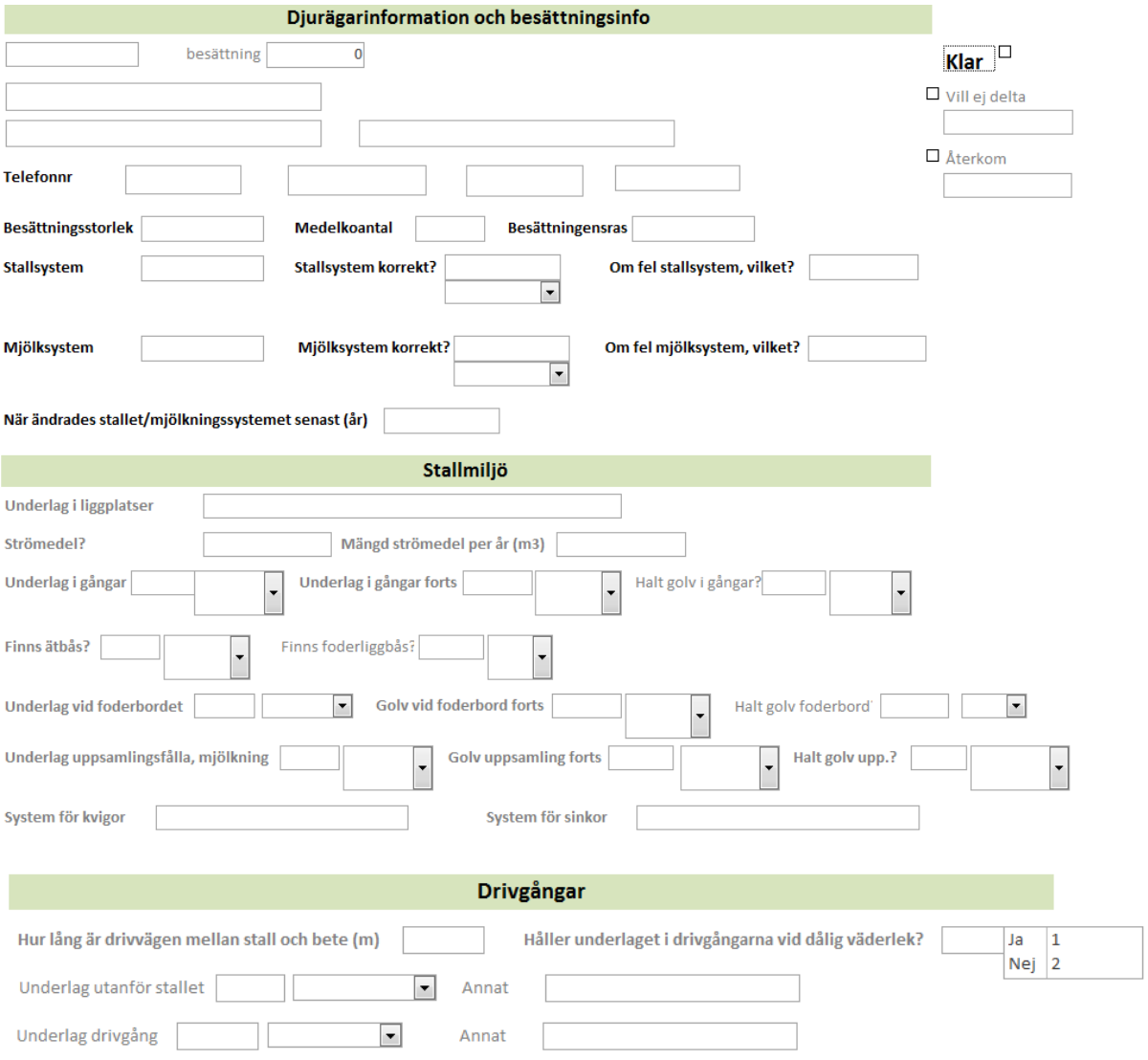
Robot study

Hygiene scoring

Figure 20 *Examples of hygiene scoring 1, 2 and 3 and 4scored at the farms in the robot study. Scoring system according to Cook (2002).*

Figure 21 *Example of hairless hock and hygiene scoring 4 on leg.*

Questionnaire study



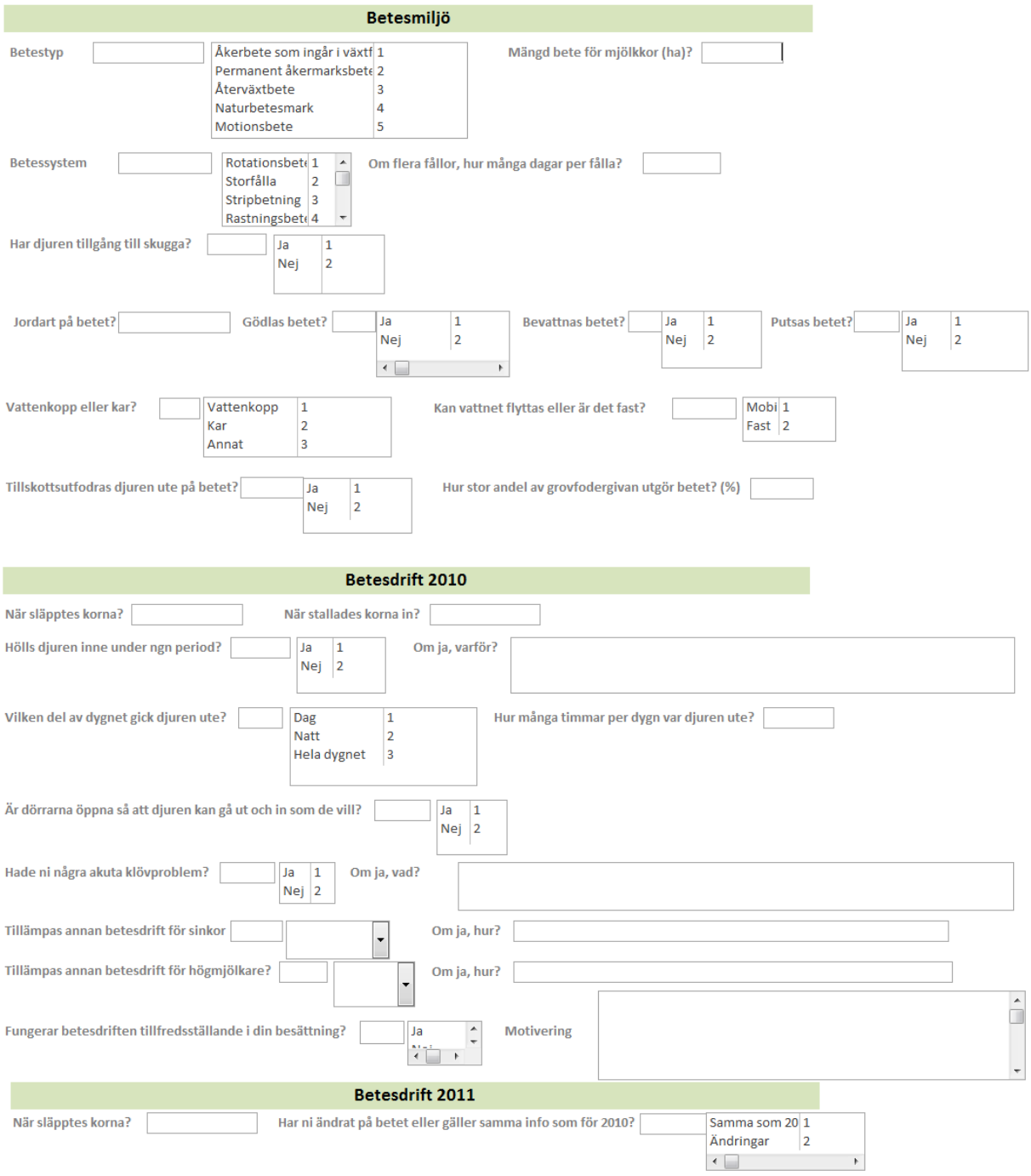


Figure 22 *Questions asked in the telephone interviews (Questionnaire study).*

Basic facts on participating farms in the questionnaire study

Table 10 *Herd sizes for farms participating in the questionnaire study*

Herd size	Number of farms	Percent
-50	12	6
50-99	93	46.3
100-199	77	38.3
200-	19	9.4
Total	201	100.00

Table 11 *Breeds for farms participating in the questionnaire study*

Breed	Number of farms	Percent
SRB*SH, other	98	49
Swedish Holstein	51	25
Swedish Red	52	26
Total	201	100.00

Table 12 *Milking systems for farms participating in the questionnaire study*

Milking system	Number of farms	Percent
Milking parlour	97	48.3
AMS	91	45.3
Rotary milking parlour	6	3
Other	3	1.4
Milking parlour and AMS	4	2
Total	201	100.00

Table 13 *Zones for farms participating in the questionnaire study*

Zone	Number of farms	Percent
Minimum 4 months	34	17
Minimum 3 months	114	57
Minimum 2 months	53	26
Total	201	100.00

Stall environment at participating farms

Table 14 *Type of beds for farms participating in the questionnaire study*

Type of beds	Number of farms	Percent
Older rubber mat	103	51.24
Cow mattress	81	40.30
Concrete	3	1.49
Waterbed	1	0.50
Deep straw bedding	3	1.49
Other	10	4.98
Total	201	100.00

Table 15 *Litter for farms participating in the questionnaire study*

Litter	Number of farms	Percent
Straw	27	13.50
Wood shavings/saw dust	136	68.00
Peat	15	7.50
Other/combinations	22	11.00
Total	200	100.00

Table 16 *Flooring in alleys for farms participating in the questionnaire study*

Flooring in alleys	Number of farms	Percent
Slatted	62	31.31
Solid	132	66.67
Slatted/solid	4	2.02
Total	198	100.00

Table 17 *Flooring in alleys 2 for farms participating in the questionnaire study*

Flooring in alleys 2	Number of farms	Percent
Concrete with pattern	68	34.52
Concrete	64	32.49
Rubber	50	25.38
Combinations	15	7.61
Totalt	197	100.00

Table 18 *Length of passage way to and from pasture for farms participating in the questionnaire study*

How long is the passage way till and from pasture	Number of farms	Percent
0-10 m	32	16.00
10-50 m	52	26.00
50-100 m	39	19.50
100-250 m	39	19.50
250-500 m	16	8.00
500m-	9	4.50
Unknown	13	6.50
Total	200	100.00

Table 19 *Ground foundation in passage ways for farms participating in the questionnaire study*

Foundation passage way	Number of farms	Percent
Gravel	68	38.64
Soil	20	11.36
Other	88	50.00
Total	176	100.00

Other materials that were used in the track ways were sand, asphalt, stone meal, wood chips, bark, macadam, lime stone gravel, rubber in different forms.

Table 20 *Foundation outside stall for farms participating in the questionnaire study*

Foundation outside stall	Number of farms	Percent
Grus	46	23.23
Betong	73	36.87
Annat	79	39.90
Total	198	100.00

Other materials that were used in the area in direct connection to the stable were sand, asphalt, stone meal, macadam, duckboard, slatted floor.

Table 21 *Answers on the question "Does the ground foundation withstand wet weather?" for farms participating in the questionnaire study*

Does the ground foundation withstand wet weather?	Number of farms	Percent
I don't know	12	6.22
Yes	75	38.86
No	91	47.15
Maybe	15	7.77
Total	193	100

Table 22 *Answer on the question "Did you keep your animals inside during some periods?" for farms participating in the questionnaire study*

Did you keep the animals inside during some periods	Number of farms	Percent
No answer (animals were not out at all)	1	0.5
Yes	141	70.5
No	58	29
Total	200	100

Table 23 *Answers on the attendant question "If yes, why?" for the previous question*

If yes, why?	Number of farms	Percent
Rainfall	122	84.72
Hot weather	2	1.39
Claw trimming/ claw health	1	0.69
Wild animals	1	0.69
Other (silage harvest, manure spreading etc.)	6	4.17
More than one of these reasons	12	8.33
Total	144	100

Table 24 *Cow hours per ha pasture and day for farms participating in the questionnaire study*

Cow hours per ha pasture and day	Number of farms	Percent
23-50	26	15.12
50-100	45	26.16
100-150	33	19.19
150-200	18	10.47
200-300	27	15.70
300-500	13	7.56
500-800	7	4.07
800-1132	3	1.74
Total	172	100.00

Table 25 *Number of farms having their cows on pasture at different times of the day for farms participating in the questionnaire study*

At what time of the day were the cows outside?	Number of farms	Percent
Day	81	41.33
Night	9	4.59
Day and night	80	40.82
Day or night	22	11.22
Day/day and night	3	1.53
Other	1	0.51
Total	196	100.00

Table 26 *Number of farms keeping the doors open to the stall for farms participating in the questionnaire study*

Are the doors open?	Number of farms	Percent
Yes	146	74.11
No	35	17.77
Yes and no	15	7.61
Unknown	1	0.51
Total	197	100.00

Table 27 *Answers to the question "Do you think that the pasture husbandry works satisfying in your herd?" for farms participating in the questionnaire study*

Do you think that the pasture husbandry works satisfying in your dairy herd?	Number of farms	Percent
Yes	157	78.89
No	22	11.06
Maybe	20	10.05
Total	199	100.00

Diagrams showing prevalence of claw health remarks, questionnaire study

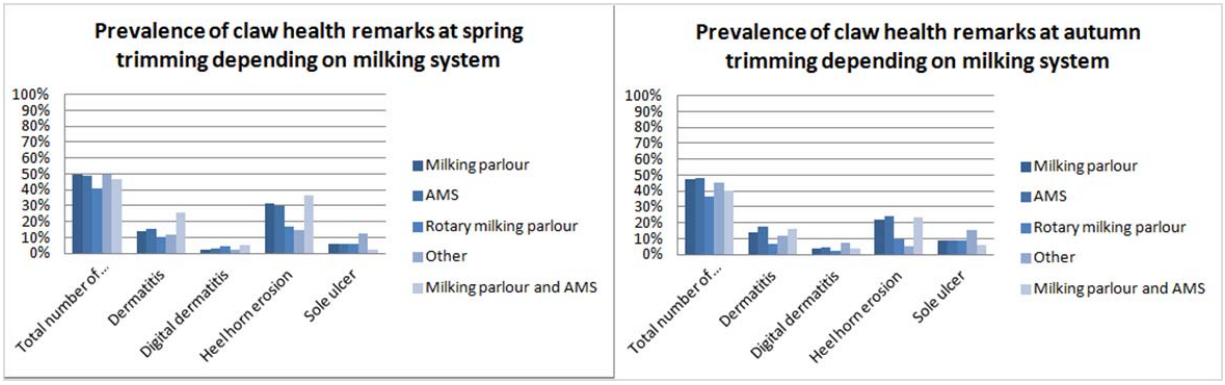


Figure 23 *Prevalence of claw health remarks depending on milking system (questionnaire study).*

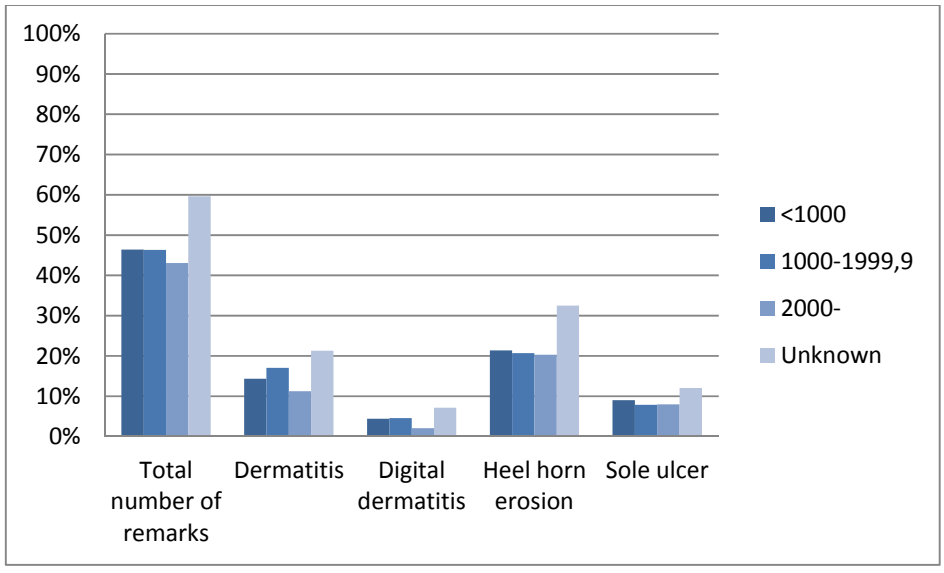


Figure 24 *Claw health remarks at trimming after housing depending on total time at pasture in hours per day multiplied by days (questionnaire study).*

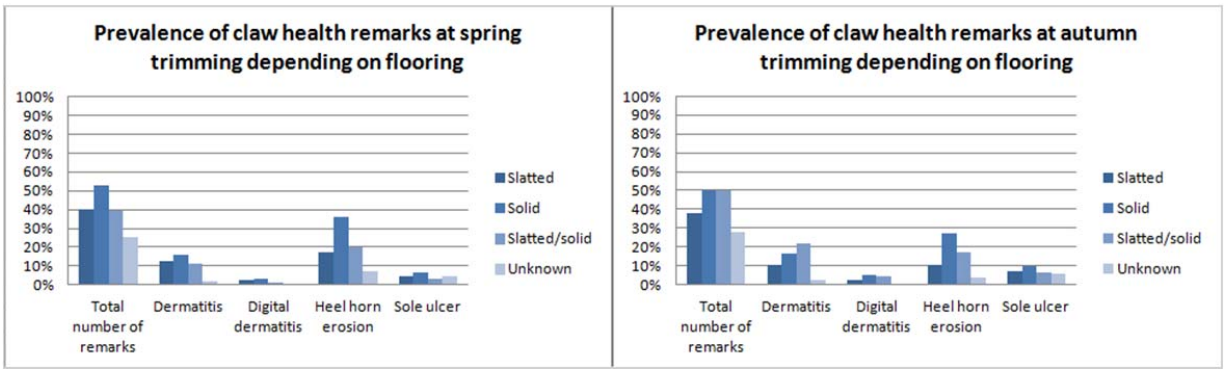


Figure 25 *Prevalence of claw health remarks at spring and autumn claw trimming depending on floor type, slatted or solid (questionnaire study).*

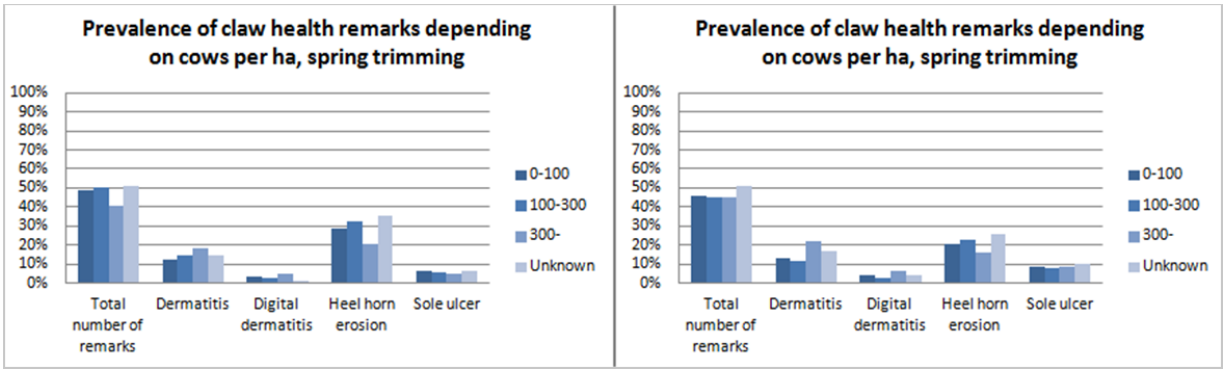


Figure 26 *Prevalence of claw health remarks at spring and autumn claw trimming depending number of cows grazed per hectare (questionnaire study).*

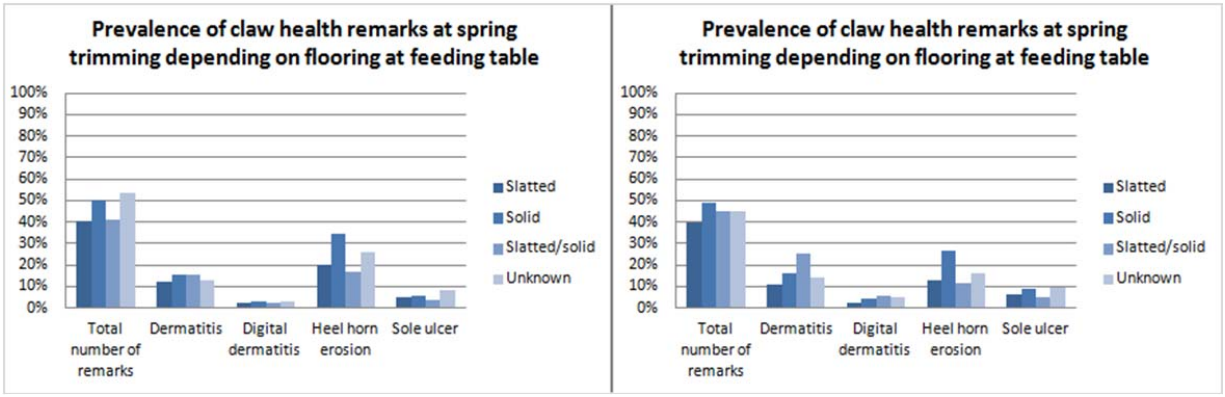


Figure 27 *Prevalence of claw health remarks at spring and autumn claw trimming depending on flooring of the feeding alley (questionnaire study).*

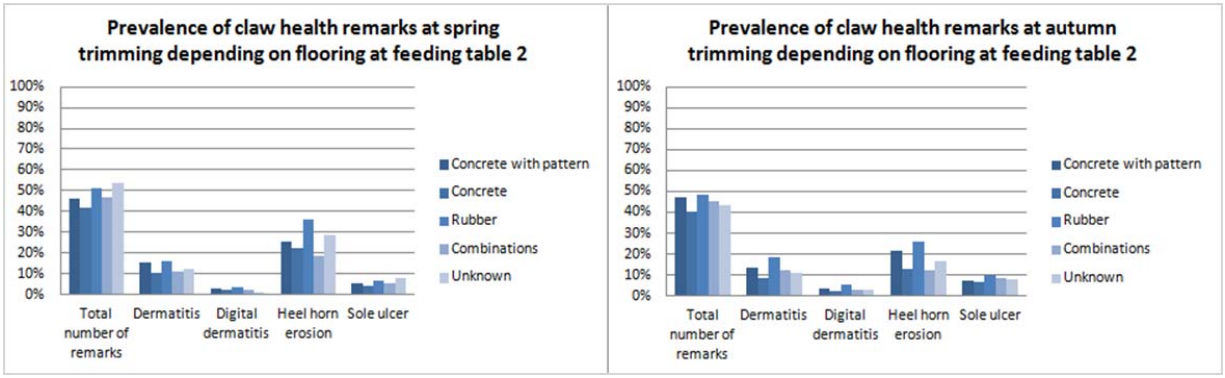


Figure 28 *Prevalence of claw health remarks at spring and autumn claw trimming depending on flooring at the feeding table 2 (questionnaire study).*

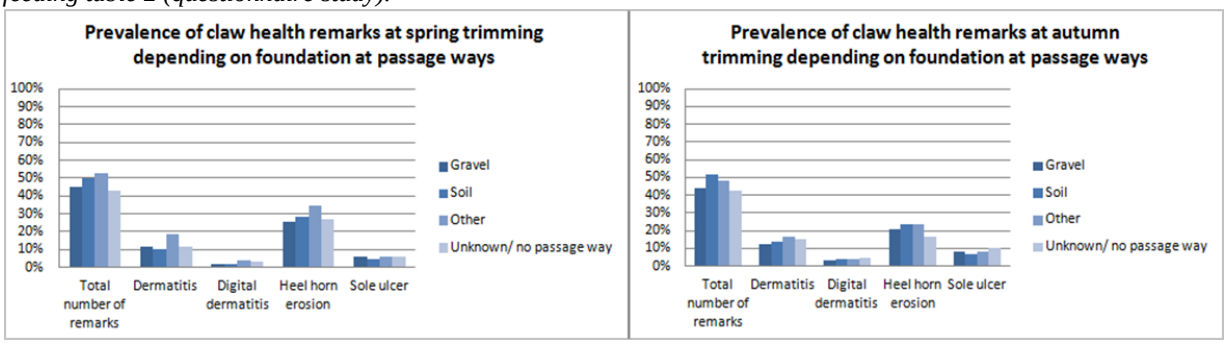


Figure 29 *Prevalence of claw health remarks at spring and autumn claw trimming depending on foundation at passageways (questionnaire study).*

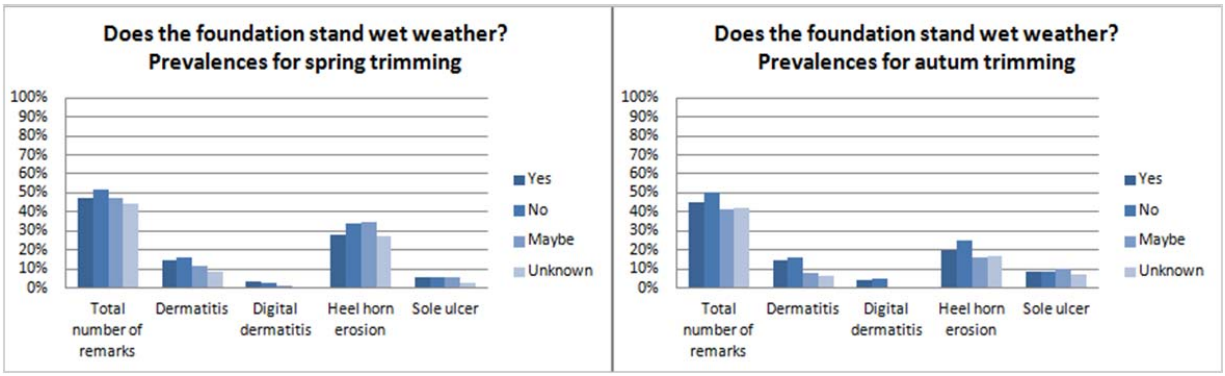


Figure 30 *Prevalence of claw health remarks at spring and autumn claw trimming depending on if the farmers stated that the foundation in the passageways did stand wet weather (questionnaire study).*

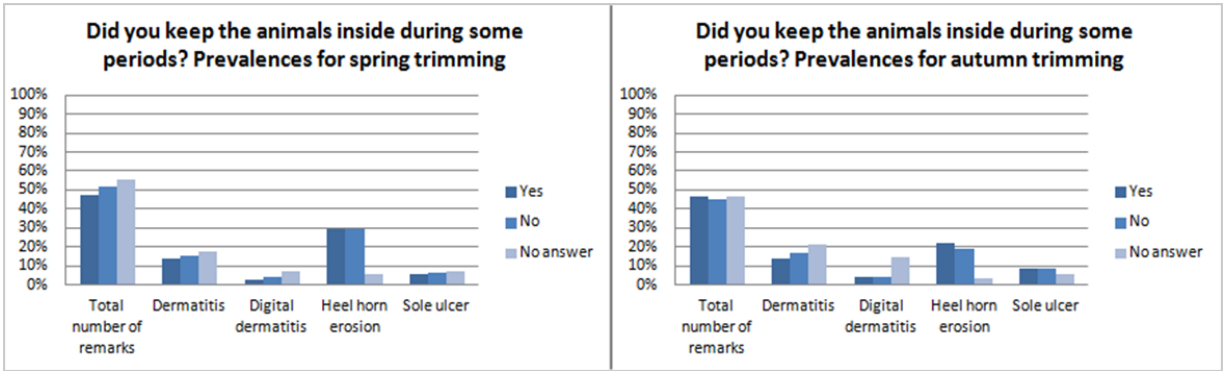


Figure 31 *Prevalence of claw health remarks at spring and autumn claw trimming depending on if the farmer stated that the cows were kept inside during some periods during the pasture season (questionnaire study).*