Swedish University of Agricultural Sciences

Department of Animal Breeding and Genetics

# Genetic Correlation Between Feet and Leg Type Traits and Claw Health in Swedish Dairy Cattle

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Supervisors:
*Jette Jakobsen*
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**Examensarbete 303**
**2008**

Examensarbete ingår som en obligatorisk del i utbildningen och syftar till att under handledning ge de studerande träning i att självständigt och på ett vetenskapligt sätt lösa en uppgift. Föreliggande uppsats är således ett elevarbete och dess innehåll, resultat och slutsatser bör bedömas mot denna bakgrund. Examensarbete på D-nivå i ämnet husdjursgenetik, 20 p (30 ECTS).

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**Agrovoc:** Genetic variation, Claw diseases, Dairy cattle
**Övrigt:** Type trait, Type trait records, Trimming records

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**ABSTRACT**

With the rapid increase in herd size over the last decade, it is imperative in modern dairy cattle farming to work for good claw health, both from an economic and animal welfare point of view. Claw health is maintained by managemental and genetical precautions. Poor claw health may result in lameness (Murray *et al*,. 1996). Among housing factors flooring is of high importance especially in loose housed animals as cows need to be able to commute comfortable between lying areas, feed troughs and milking facilities to stay healthy. Claw diseases and lesions have been recorded by foot trimmers at maintenance foot trimming in Sweden since 1996 and is a potential new trait for genetic evaluations.

The aim of this study was to estimate genetic correlations between claw diseases (dermatitis, heel horn erosion, sole haemorrhage and sole ulcer) recorded by claw trimmers and some feet and leg type traits (rear leg side view, rear leg rear view, hock quality, bone structure and foot angle) measured by educated classifiers. The purpose was also to estimate heritabilites and genetic correlations among type traits. The data was based on observations from Swedish Holstein (SH) and Swedish Red (SR) in their first lactation. The records were collected for the Swedish Dairy Association by claw trimmers and type trait classifiers from year 2000 to 2007 in 144 898 SH and 142 647 SR. Of these, 99 835 SH and 104 227 SR were scored for type traits while 65 789 SH and 58 457 SR were scored by claw trimmers.

The results show that the heritabilites for type traits were low to medium high for both breeds. Foot angle had the lowest heritability (0.11 for SH and 0.10 for SR) while bone structure had the highest heritability (0.23 for SH and 0.31 for SR). The genetic correlations were low for both breeds, with the lowest value of -0.001 (foot angle versus bone structure) for SH and -0.02 (rear leg side view versus hock quality) for SR. The highest correlations of type traits were very high with 0.87 for SH and 0.92 for SR (bone structure versus hock quality). The correlations between type traits and claw disorders were low but in general higher for SR than SH. The highest correlations for SH were found between rear leg side view and the different claw disorders with a range between 0.13 to 0.28. For SR, the highest correlations were found between hock quality and bone structure and the different claw disorders, -0.10 to -0.31 and -0.17 to -0.24 respectively.

The heritabilites and genetic parameters for type trait data were similar to other international studies. Some breed differences were found for genetic correlations between type traits and claw disorders. The genetic correlations were non-significantly different from zero for most traits in SH or low for SR Thus, indirect selection for improved claw health using type trait data was not found possible. Accordingly, it is of highest importance to continue recording of claw health as a direct way of genetic improvement of claw health instead of the indirect selection via type traits.

**SAMMANFATTNING**

Under det senaste decenniet har besättningsstorleken och andelen lösdriftbesättingar i svensk mjölkproduktion ökat kraftigt vilket ställer särskilt höga krav på en god klövhälsa. Dålig klövhälsa kan resultera i hälta (Murray *et al,*. 1996), vilket inverkar negativt på både ekonomi och på djurens välfärd. Kons klövhälsa påverkas dels av skötsel- och miljöfaktorer och dels av genetiska faktorer. Särskilt i lösdrift är golvkvaliteten avgörande för kons förmåga att röra sig mellan vila, mat och mjölkning och för att hålla klövarna friska. Klövhälsa hos svenska kor har registrerats av klövvårdare i samband med rutinmässig klövverkning sedan 1996 och är nu aktuell för att användas vid avelsvärdering.

Syftet med studien var att skatta genetiska parametrar för klövsjukdomar (klöveksem, klövröta, sulblödning och klövsulesår) och exteriöregenskaper (ben bakifrån, hasvinkel, haskvalitet, benbyggnad och fotvinkel) för att se om dessa var genetiskt korrelerarde. Materialet baserades på observationer från Svensk Holstein (SH) och Svensk röd boskap (SR) i deras första laktation insamlade av klövvårdare mellan åren 2003 och 2007 och av exteriörbedömare mellan åren 2000 och 2007. Totalt inkluderades 144 898 SH och 142 647 SR varav 99 835 SH och 104 227 SR som var exteriörbedömda och 65 789 SH och 58 457 SR där klövarna verkats och bedömts.

Resultaten visade att arvbarheten för exteriöregenskaperna, för båda raserna, var låga till medelhöga med lägsta arvbarheten för fotvinkel (0.11 för SH och 0.10 för SR) och högsta arvbarheten för benbyggnad (0.23 för SH och 0.31 för SR). Korrelationerna mellan exteriöregenskaperna var låga för båda raserna med lägsta värdet -0.001 (fotvinkel mot benbyggnad) för SH och -0.02 (hasvinkel mot haskvalitet) för SR. Högsta värdet var mycket högt för benbyggnad mot haskvalitet med 0.87 för SH och 0.92 för SR. Korrelationerna mellan exteriöregenskap och klövsjukdom var generellt låga men högre för SR än SH. För SH var de starkaste korrelationerna mellan hasvinkel och de olika klövsjukdomarna (0.13 till 0.28). De starkaste korrelationerna för SR fanns mellan haskvalitet korrelerat till de olika klövsjukdomarna (-0.10 till -0.31) samt för benbyggnad korrelerat till de olika klövsjukdomarna (-0.17 till -0.24).

Arvbarheten för och de genetiska korrelationerna mellan exteriöregenskaperna var samstämmiga med resultat från andra internationella studier. Vissa rasskillnader noterades för de genetiska korrelationerna mellan klöv- och exteriördata, där de flesta korrelationer för SH var icke signifikant skilda från noll, medan SR hade låga korrelationer mellan de olika egenskaperna. Resultaten visar att indirekt selektion för att få en bättre klövhälsa genom att avla för exteriöregenskaper inte är möjlig. Det är fortsatt viktigt att klövvårdare fortsätter att registrera klövsjukdomar då detta ger oss bättre information för genetisk förbättring av klövhälsan jämfört med indirekt selektion via exteriöregenskaper.

## INTRODUCTION

Because of farmers strive for greater efficiency to produce high quality products with competitive prices, there are great demands on dairy cows' health and performance. Our breeding goal is high milk producing healthy cows with a good herd life and with animal welfare in mind (Eriksson, 2007; Distl *et al.*, 1990). Feet and leg disorders were the third most common health problem for culling, only reproduction and mastitis were more common (APHIS, 2006; McDaniel, 1997). Poor feet and leg health does not only cause impaired animal welfare, pain for the cow (Van der Waiij *et al.*, 2005; McDaniels, 1997) but also reduced economic return for the farmer. Such examples are direct cost as veterinary treatments (Nielsen *et al.*, 1997), direct losses like lower production, discarded milk, and indirect losses as decreased herd life and increased length of calving interval (Koenig *et al.*, 2005; Van Dorp, 2004). Although studies show an unfavourable correlation between lameness, feet and leg disorders and milk production, health problems and fertility (Warnick *et al*. 2001, Green *et al*. 2002 Hultgren *et al.*, 2004), the claw disease complex and its genetic components has, to date, been scarcely studied and should be further investigated owing to its importance (Koenig *et al*., 2005; Ral, 1999).

The high and steadily increasing level of milk production causes excessive wear to the body, especially to the feet and legs (Koenig *et al*., 2005). Cows housed in cubicles have more freedom to move and get exercise, which results in better type trait scores than for cows housed in tied stalls (Fatehi *et al.,* 2003). The disadvantage is that cubicle housed cows are more exposed to a dirtier and rougher foot environment than in tie stalls. For example, liquid manure may loosen up the claw horn and claw skin with risk of chemical and microbial damage as consequences (Bergsten, 1997). Thus it is not surprising that feet and leg disorders are more common in cubicles than in tie stalls (Hultgren, 2002; Sogstad, 2005) and cow comfort and soft clean environment is most important.

Claw health is currently not included in the breeding program but could potentially be improved through indirect selection for feet and legs type traits, which are correlated with claw disorders (Van der Waaij *et al.*, 2005). However, this is only possible if the correlations are strong enough (0.5-0.6).

The purpose of this study was to estimate genetic parameters and genetic correlations between, feet and leg type traits and claw disorders, for Swedish Red and Swedish Holstein first lactation cows, to estimate the possibility of indirect breeding for good claw health.

## LITERATURE REVIEW

### Feet and legs type traits

Strong feet and legs prolong herd life of dairy cattle which is strong motivation to include feet and legs type traits breeding programs in many countries (Buitenhuis *et al.*, 2007). The five feet and legs type traits: rear leg side view (RLSV), rear leg rear view (RLRV), hock quality (HQ), bone structure (BS) and foot angle (FA) here studied are included in the Nordic Cattle Genetic Evaluation (NAV), which is a joint genetic evaluation system established by the three countries Sweden, Denmark and Finland (Nordic Cattle Genetic Evaluation website, 2007). One of the goals of NAV is to strengthen the selection for health traits, e.g. type traits, to breed for a healthier animal (Johansson *et al.*, 2006). Of these five type traits mentioned above, only RLSV, RLRV and FA are official linear traits defined by the World Holstein Friesian Federation, (2005). The traits are scored by a linear classification scoring system from 1 to 9 (Appendix 1), often as in Sweden and Denmark in the first lactation cows (Fogh *et al.*, 2004; Nordic Cattle Genetic Evaluation website, 2007). The type trait report (Appendix 1) includes information about herd, cow, classifier, date of classification and scores for linear and secondary type traits (Swedish Dairy Association, 2003).

Koenig *et al.* (2005) found that bulls that transmitted straighter leg viewed from the rear side had fewer daughters with claw and feet disorders and McDaniels, (1997) found that cows with straighter RLRV and higher FA had an improved herd life and were more desirable for the farmer. Table 1 shows the optimum score for the five type traits recorded in Sweden (Swedish Dairy Association, 2008; Principles of Danish Cattle Breeding website, 2006).

***Table 1***. The optimum score among the five type traits for Swedish Holstein (SH) and Swedish Red (SR) (from Swedish Dairy Association, 2008)

| | Optimum score | |
|---|---|---|
| Traits[1] | SH | SR |
| RLSV | 5 | 5 |
| RLRV | 8 | 8 |
| HQ | 9 | 9 |
| BS | 8 | 7.5 |
| FA | 6.5 | 7 |

[1] RLSV = rear leg side view, RLRV = rear leg rear view, HQ = hock quality, BS = bone structure and FA = foot angle.

*Rear leg side view, RLSV*

A guide for scoring rear leg side view is shown in Figure 1a**.** An optimal angle at the hock is considered to be 150-155 degrees. Score 1 describes a very straight leg with a wide angle, while score 9 describes a very sickled leg with a smaller angle (Nordic Cattle Genetic Evaluation website, 2007).

*Rear leg rear view, RLRV*

A guide for scoring rear leg rear view is shown in Figure 1b**.** The score depends on the distance between the hocks seen from the rear. A cow with very close hocks and extremely toe-out gets score 1. Score 9 is given if the distance between the hocks is bigger than the distance between the claw clefts (Nordic Cattle Genetic Evaluation website, 2007).

*Hock quality, HQ*

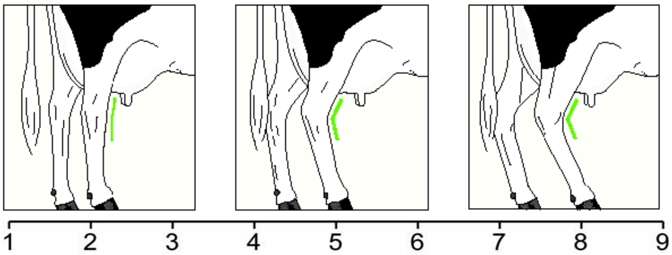
The quality of the hock (Figure 1c) is evaluated both from the back and from the side. Score 9 is given for a hock that is completely clean and dry without any swellings. A hock that is filled with a lot of fluid (swellings) receives score 1 (Nordic Cattle Genetic Evaluation website, 2007).

*Bone structure, BS*

The structure of the bone (Figure 1d) is judged by looking at the rear legs. The width and the thickness of the bones are measured by estimating the rear leg from behind and from the side. Bones that are very fine and thin receive score 9 whereas bones that are broad and thick receive score 1 (Nordic Cattle Genetic Evaluation website, 2007).

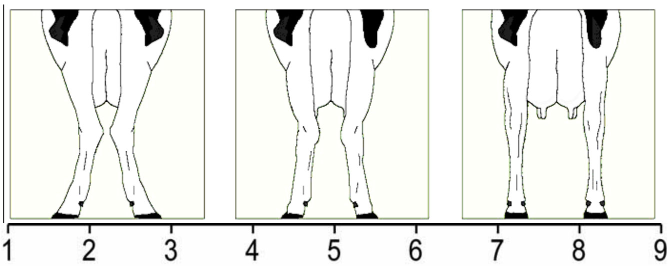
*Foot angle, FA*

The foot angle (Figure 1e) is measured at the right hoof and describes the angle between the floor and the front slope of the claw. Score 1 describes a low slope (~15 degrees) and score 9 describe a steep slope (~65 degrees). Score 5 is given if the angle is about 45 degrees (World Holstein Friesian Federation website, 2007).



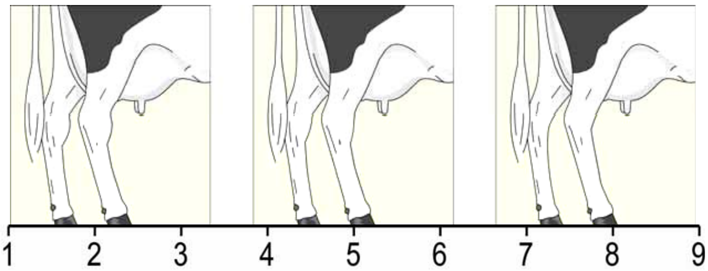

Straight Intermediate Sickled

***a)*** Description how to judge RLSV.



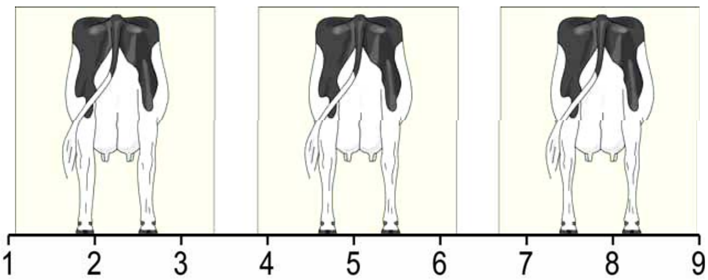

Toes out Intermediate Parallel bowed-legged

***b)*** Description how to judge RLRV.



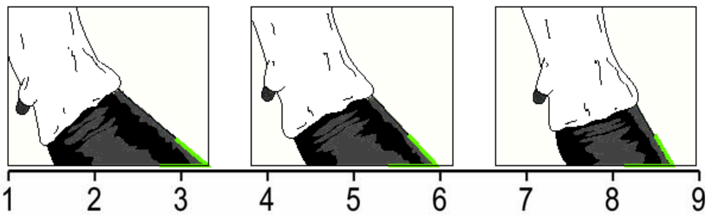

Filled Intermediate Dry

***c)*** Description how to judge HQ.




Coarse Intermediate Fine & thin

***d)*** Description how to judge BS.




Low Intermediate Steep

***e)*** Description how to judge FA.

***Figures 1a-e*** show how to judge RLSV, RLRV, FA, BS and HQ (Nordic Cattle Genetic Evaluation website, 2007)

## Claw diseases

Claw health can be included in the breeding program through indirect selection for feet and legs type traits (Van der Waaij *et al.*, 2005) if the heritabilites are reasonably high and the correlations with claw diseases are strong enough. Claw diseases can be observed by claw trimmers at regularly trimming and in Sweden claw diseases found at trimming are recorded in a claw health report, Appendix 2 (Swedish Dairy Association, 2007b). In this report herd- and claw trimmer number, date and ID of each trimmed cow are noted. Most common claw disease (dermatitis, heel horn erosion, sole haemorrhage and sole ulcer), are scored as mild or severe and also locomotion, claw shape, other diseases, treatments and comments are reported. The status of sole ulcer (unlike the other three lesions) is reported per claw, because of farmers' interest to be able to follow up the lesion (Swedish Dairy Association, 2007b).

### *Dermatitis*

Dermatitis (Figure 2a) is an inflammation of the digital and/or interdigital skin. The first sign of dermatitis is lengthening of the hair in the border between skin and horn and a redness of the skin (Manske *et al*., 2002). Mild dermatitis does not cause lameness and can be hard to detect if the claws are not cleaned. In severe dermatitis the skin is ulcerated and is known as digital dermatitis. Severe lesions are soar and cause lameness. Common consequences of dermatitis are heel horn erosion and limax (interdigital hyperplasia; Appendix 3).

### *Heel horn erosion*

Heel horn erosion (Figure 2a) is in simple terms a *deficit of horn tissue of the bulbs (heel horn)* recognized as V-shaped erosions and clefts (Manske *et al.,* 2002). The heel horn can also be affected with circular craters. Heel horn erosion is more common in the rear legs and it is often double-sided (Appendix 3). Lameness is not often observed (Manske *et al.,* 2002). Heel horn erosion is together with dermatitis the two most common contagious disorders among dairy cattle (Bergsten, 1997).

### *Sole haemorrhage*

Sole haemorrhage (Figure 2b) is characterized by red or yellow discoloration of the sole horn and/or the white line (Appendix 3). The sole haemorrhages can be a good indicator of earlier present laminitis, an inflammation of the connective and horn producing tissue (corium) of the claw. The inflammation leads to a weaker attachment of the claw bone to the claw capsule and the location of claw bone may change causing damage of the corium and impaired horn quality, double sole, sole haemorrhages, white line disease and sole ulcer (Bergsten, 1996). Haemorrhages of the corium are staining the sole horn which grows slowly to the surface where they can be recognized at trimming. If the injured area is not unloaded, by for example trimming, a sole ulcer may result

### *Sole ulcer*

Sole ulcer (Figure 2c) is a defect through the sole of the claw capsule with exposed corium (Manske *et al.*, 2002), e.g. Sole ulcer is a painful disorder and is a common cause of lameness (Appendix 3). This can cause a generally lower titillation threshold due to long term suffering (Whay *et al.* 1998). Sole ulcer is also very expensive due to long lasting reduction of the performance and other costs (Oskarsson, 2008).

a) b) c)

***Figure 2a-c.*** a) dermatitis, and heel horn erosion, b) sole haemorrhage, c) sole ulcer (Appendix 3).

### Genetic and phenotypic correlations between type traits and claw diseases

Van der Waiij *et al.* (2005) estimated correlations between claw disorders and type traits. The data was based on claw health and type traits in 15 364 Holstein-Friesian cows collected from May 2002 to October 2003. Claw trimming and type records records were normally collected during the first month of the first lactation independently of each other on different days. Claw disorders included in this study were: sole haemorrhage, interdigital dermatitis heel horn erosion, digital dermatitis, sole ulcer, white line disease, interdigital hyperplasia (limax) and interdigital phlegmona (foot rot) and type traits were RLSV, RLRV and FA. The genetic correlations were low to mid-high and are shown in Table 2**.** The phenotypic correlations were overall very low, and ranged from –0.08 to 0.05.

***Table 2.*** Genetic correlations (SE) between claw disorders and type traits (from Van der Waiij., 2005)

| Trait[1] | RLSV | RLRV | FA |
|---|---|---|---|
| DD | 0.16 (±0.13) | -0.21 (±0.15) | -0.22 (±0.13) |
| IDHE | 0.27 (±0.13) | -0.10 (±0.16) | -0.31 (±0.14) |
| SH | 0.13 (±0.15) | 0.14 (±0.18) | 0.11 (±0.16) |
| SU | 0.16 (±0.22) | -0.07 (±0.28) | -0.05 (±0.24) |

[1] DD = digital dermatitis, IDHE = interdigital dermatitis heel horn erosion SH = sole haemorrhage, SU = sole ulcer, RLSV = rear leg side view, RLRV = rear leg rear view and FA = foot angle.

Koenig *et al.* (2005) estimated genetic correlations between type traits (RLSV, RLRV and FA) and claw disorders (digital dermatitis and sole ulcer). The traits were recorded in 5634 Holstein cows, in nine different herds during 2003. The genetic correlations were mid-high to high and are shown in Table 3.

***Table 3.*** Genetic correlations between claw disorders and type traits (from Koenig *et al.*, 2005)

| Trait[1] | RLSV | RLRV | H | FA |
|---|---|---|---|---|
| DD | -0.49 | 0.50 | 0.30 | -0.61 |
| SU | -0.31 | 0.48 | -0.22 | 0.29 |

[1] DD = digital dermatitis, SU = sole ulcer, RLSV = rear leg side view, RLRV = rear leg rear view, H = hocks and FA = foot angle.

## Correlations and heritabilities among type traits

Much research has been done on correlations among feet and legs type traits, especially for RLSV and FA. The five type traits that were written about in section "feet and legs type traits" are part of the genetic evaluation run by NAV (Principles if Danish Cattle breeding, 2006). The heritabilities used in NAV are shown in Appendix 4.

Van der Waiij *et al.* (2005) estimated correlations and heritabilities on data collected from 21 611 Holstein-Friesian cows from May 2002 to October 2003. Almost all the records were gathered during the first month of lactation. The results include RLSV, RLRV and FA. Heritabilites are shown in Appendix 4 and correlations are presented in Table 4.

Pérez-Cabal *et al*. (2006) studied type trait data from 62293 Holsteins collected from 1979 to 2003 mainly in their first lactation. Heritabilites are shown in Appendix 4 while genetic correlations between RLSV and FA are shown in Table 4**.** Heritiablities and correlations for RLSV and FA were estimated for 58 942 Holstein cows, collected from January 1983 through May 1985 in a study by Lawstuen *et al.* (1986). The cows were divided into five age groups; 2, 3, 4, 5-year-olds and age ≥ 6. Only the group of 2-year-old, 14 786 cows, will be presented in this literature review. Boelling, (1997) studied type traits from 31 768 Holstein cows and her and the other results from above are shown in Table 4.

***Table 4.*** Genotypic ( $r_g$ ) and phenotypic ( $r_p$ ) correlations among type traits by different references

| Trait | Breed | $r_g$ | $r_p$ | Reference |
|---|---|---|---|---|
| RLSV & RLRV | Holstein - Fresian | -0.20 (0.01) | -0.12 (0.14) | Van der Waaij *et al.*, 2005 |
| RLSV & FA | - | 0.26 (0.14) | -0.46 (0.01) | - |
| RLSV & FA | Holstein | -0.59 | -0.14* | Lawstuen *et al.*, 1986 |
| RLSV & FA | - | 0.44 (0.032) | | Pérez-Cabal et al., 2006 |
| RLRV & FA | Holstein -Fresian | -0.72 (0.07) | 0.31 (0.01) | Van der Waaij *et al.*, 2005 |
| RLRV & FA | Holstein | -0.37 | -0.39 | Boelling, 1997 |

* Phenotypic correlations > .01 significantly (P< .05) different from zero.
[1] RLSV = rear leg side view, RLRV = rear leg rear view and FA = foot angle.

Van Dorp *et al.* (1997; 2005) showed heritabilities of type traits in two studies using 3298 Holstein cows (26 herds) and 4368 Holsteins (30 herds) in their first lactation, respectively (Appendix 4). Here, RLSV, BQ and FA are of most interest. Pérez-Cabal *et al.*, 2002 also estimated heritabilities for RLSV and FA in their study of 46 316 Spanish Holsteins (Appendix 4).

In a study by Boelling *et al.* (2001), genetic correlations and heritabilities for feet and legs type traits (RLSV, RLRV, HQ, BS and FA) were estimated from 11 846 Danish Red, 62 875 Danish Friesian and 10 954 Jersey cows. They were all scored in their first lactation. Heritabilities are shown in Appendix 4 and genetic correlations are shown in Table 5.

***Table 5.*** Genetic correlations among type traits for different breeds (from Boelling *et al.*, 2001)

| | Danish Red | | | | Danish Friesian | | | | Jersey | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trait[1] | RLRV | HQ | BS | FA | RLRV | HQ | BS | FA | RLRV | HQ | BS | FA |
| RLSV | -0.14 | **0.21** | **-0.14** | **-0.26** | **-0.22** | 0.04 | 0.01 | **-0.46** | 0.15 | -0.02 | 0.09 | **-0.40** |
| RLRV | | 0.12 | 0.10 | 0.09 | | **0.22** | **0.17** | **-0.23** | | 0.11 | **0.32** | -0.11 |
| HQ | | | **0.70** | **-0.19** | | | **0.78** | -0.04 | | | **0.72** | **-0.26** |
| BS | | | | **-0.16** | | | | -0.06 | | | | 0.10 |

Statistically significant correlations are in bold.
[1] RLSV = rear leg side view, RLSV = rear leg side view, HQ = hock quality, BS = bone structure and FA = foot angle.

Boelling *et al.* (2007), used first lactation data collected from 2004 trough 2007 from 28 320 Red Danish, 150 823 Holstein cows and 28 109 Jerseys. Heritiabilities and genetic correlations were estimated for locomotion and type traits (Appendix 4).

Wiggans *et al.* (2004) and Gengler *et al.* (1999) estimated heritabilities and correlations for different type traits (RLSV and FA) from five different dairy breeds: Ayrshire, Brown Swiss, Guernsey, Jersey and Milking Shorthorn (Appendix 4). The study from 2004 used records collected from year 1995 whereas the study from 1999 used records collected from year 1988. Table 6 shows number of cows per breed included in the two studies. The estimated genetic correlations were ranged between –0.29 and –0.49 in the study by Wiggans *et al.* (2004) and between –0.30 and –0.54 in the study by Gengler *et al*. (1999). The phenotypic correlations had a range from –0.19 to -0.29 in the study by Wiggans *et al.* (2004) and from –0.17 to –0.26 in the study by Gengler *et al.* (1999).

***Table 6.*** Number of cows and (herds) of the five breeds (from Wiggans *et al.* 2004 and Gengler *et al.*, 1999)

| | Study | |
|---|---|---|
| Breed | Wiggans *et al*, 2004 | Gengler *et al*, 1999 |
| Ayrshire | 8 854 (494) | 4 700 |
| Brown Swiss | 21 560 (183) | 14 382 |
| Guernsey | 16 332 (113) | 24 253 |
| Jersey | 23 811 (45) | 19 741 |
| Milking Shorthorn | 3 762 (211) | 2 182 |

In another study by Wiggans *et al.* (2006), they estimated heritabilities for and correlations between RLRV and other type traits (RLSV and FA are reported). The records were collected from 2004 and later from 7676 Brown Swiss and 5437 Guernsey dairy cattle. The estimated genetic correlations were strongest for Guernsey cows, with –0.46 between RLRV and RLSV and 0.31 between RLRV and FA, correlations for Brown Swiss estimated to -0.11 and 0.19, respectively. The phenotypic correlations were also strongest for Guernsey cows with –0.19 and 0.21, respectively, compared to –0.16 and 0.19 for Brown Swiss cows. Appendix 4 shows the heritabilities for the different breeds and type traits.

Heritabilities for RLSV, RLRV, HQ and FA in Swiss Simmental and Red & White cattle were estimated in a study by Vukasinovic *et al.* (2002; Appendix 4).
The correlations between type traits and claw disorders had a range from very low to mid-high. Boelling *et al.* (2001) estimated high genetic correlations between bone

structure and hock quality for Danish Red, Danish Friesian and Jersey (0.70, 0.78 and 0.72, respectively). The high correlation may be due to the great similarities between those traits.

### Heritabilities for and correlations among claw diseases

Van der Waaij *et al*. (2005) estimated correlations and heritabilities from 21 611 Holstein-Friesian cows, collected between May 2002 and October 2003. The study comprised results from four different claw disorders: sole haemorrhage, interdigital dermatitis and heel horn erosion, digital dermatitis, and sole ulcer. The results are presented in Table 7.

***Table 7.*** Heritabilities (diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations among claw disorder traits (±SE) (from Van der Waaij *et al.*, 2005)

| Traits[1] | DD | IDHE | SH | SU |
|---|---|---|---|---|
| DD | **0.10** ± **0.02** | 0.74 ± 0.09 | -0.12 ± 0.16 | -0.18 ± 0.25 |
| IDHE | 0.11 ± 0.01 | **0.05** ± **0.01** | 0.13 ± 0.17 | -0.11 ± 0.25 |
| SH | 0.01 ± 0.01 | 0.04 ± 0.01 | **0.08** ± **0.02** | 0.81 ± 0.26 |
| SU | -0.00 ± 0.01 | 0.01 ± 0.01 | 0.08 ± 0.01 | **0.01** ± **0.01** |

[1] DD = digital dermatitis, IDHE = interdigital dermatitis heel horn erosion, SH = sole haemorrhage and SU = sole ulcer.

Naeslund, (2007) estimated correlations and heritabilities for, and between claw health (traits; dermatitis, heel horn erosion, sole haemorrhage and sole ulcer) in Swedish Holstein (SH) and Swedish Red (SR) cows in the first and second lactation in her master thesis. Only results from the first lactation is reported in this study (Table 8 and 9)

***Table 8.*** Heritabilities (diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations among claw disorder traits for SH (±SE) (Naeslund, 2007)

| Traits[1] | DE | HE | SH | SU |
|---|---|---|---|---|
| DE | **0.069** | 0.640 ± 0.067 | 0.085 ± 0.102 | 0.008 ± 0.105 |
| HE | 0.122 | **0.046** | 0.290 ± 0.102 | 0.305 ± 0.104 |
| SH | 0.003 | 0.059 | **0.034** | 0.715 ± 0.080 |
| SU | -0.001 | 0.076 | 0.060 | **0.033** |

[1] DE = dermatitis, IDHE = interdigital dermatitis heel horn erosion, SH = sole haemorrhage and SU = sole ulcer.

***Table 9.*** Heritabilities (diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations among claw disorder traits for SR (±SE) (Naeslund, 2007)

| Traits[1] | DE | HE | SH | SU |
|---|---|---|---|---|
| DE | **0.040** | 0.864 ± 0.046 | -0.017 ± 0.112 | -0.037 ± 0.127 |
| HE | 0.125 | **0.044** | 0.352 ± 0.093 | 0.294 ± 0.112 |
| SH | 0.019 | 0.066 | **0.059** | 0.703 ± 0.072 |
| SU | 0.004 | 0.072 | 0.064 | **0.038** |

[1] DE = dermatitis, IDHE = interdigital dermatitis heel horn erosion, SH = sole haemorrhage and SU = sole ulcer.

Koenig *et al.* (2005) estimated heritability and genetic correlations from 5634 Holstein cows in their study. The results from the two disorders, dermatitis and sole ulcer, are shown in Table 10.

***Table 10.*** Heritabilites (diagonal) and genetic correlations (above diagonal) among claw disorder traits (from Koenig *et al.*, 2005)

| Traits[1] | DD | SU |
|---|---|---|
| DD | **0.073 ± 0.009** | 0.561 ± 0.073 |
| SU | | **0.086 ± 0.006** |

[1] DD = digital dermatitis and SU = sole ulcer.

Boelling *et al.* (2001) estimated heritabilities for interdigital dermatitis in their study. The records were collected from 11 846 Danish Red, 62 875 Danish Friesian and 10 954 Jersey cows. The heritabilities (SE) were 0.11 (0.03), 0.09 (0.02) and 0.02 (0.02), respectively.

Both Van der Waiij *et al*. (2005) and Naeslund, (2007) showed high correlations between dermatitis-heel horn erosion and sole haemorrhage-sole ulcer in their studies. This might be due to the close relationship between those disorders. The remaining correlations were low.

## Locomotion

According to Danish studies locomotion affects feet and leg type traits. This has, however, been scarcely studied and the results are therefore not completely trustworthy. Locomotion is not a part of my own study, but because other studies have shown correlations to all five type traits, it is important and of some interest to include in this thesis. Lameness is a large disease complex causing impaired animal welfare (Alban *et al.,* 1996; Boelling *et al.,* 2007; McDaniel, 1997) and a way to judge lameness severity is through locomotion scoring. Locomotion is scored on a linear scale, often from complete lameness to perfect gait (Boelling *et al.*, 2007). Denmark is the only country in NAV, to date, that scores for locomotion. This is, however, only on test basis (Interbull Website, 2007). Boelling *et al.* (1997) showed in a study that locomotion score decreases significantly with ageing, which indicates that feet and leg health plays a more important role in later life. The study also showed that younger cows in general had straighter RLSV than older cows and according to Boettcher *et al.* (2004) and Van Dorp *et al.* (2004), straighter legs and steeper foot angle was associated with better locomotion. To measure locomotion, the cow walks a few meters in front of the evaluator on a non-slippery surface without disturbance. It is desirable to collect more records on this trait but due to practical necessities (time consuming) only one third of the cows could be scored for locomotion (Boelling *et al*., 2007).

Boelling *et al.* (2007) used locomotion data collected 2004 through 2007 from Red Danish, Holstein and Jersey cows in their study. Only first lactations data were included and the locomotion scores were going from complete lameness to perfect gait. Heritabilities and genetic correlations were estimated for locomotion and type traits. The heritabilities for locomotion were 0.10 for Red Danish, 0.07 for Holstein and 0.05 for Jersey. Table 11 shows the number of type traits and locomotion records per breed while Table 12 shows the genetic correlation of locomotion among type traits. The same results, heritabilities and genetic correlations (Table 12), were shown in Ny KvaegForskning Website, (2007). A few things differ from Boelling *et al.*, 2007; instead of hocks and BQ Ny KvaegForskning Website, (2007) named it HQ and BS, respectively. The BQ heritability for Holstein was 0.01 instead of 0.002 estimated by Boelling *et al.* (2007).

***Table 11.*** Number of type trait respectively locomotion records per breed (from Boelling *et al.*, 2007)

| | Type Traits | Locomotion |
|---|---|---|
| Red Danish | 28 320 | 6 307 |
| Holstein | 150 823 | 56 470 |
| Jersey | 28 109 | 7 196 |

***Table 12.*** Genetic correlation between locomotion and feet and legs type traits (from Boelling *et al.*, 2007)

| Trait[1] | Red Danish | Holstein | Jersey |
|---|---|---|---|
| RLSV | -0.77 ± 0.12 | 0.03 ± 0.09 | 0.11 ± 0.23 |
| RLRV | 0.81 ± 0.10 | 0.73 ± 0.06 | 0.47 ± 0.20 |
| H | 0.41 ± 0.15 | 0.11 ± 0.09 | -0.11 ± 0.22 |
| BQ | 0.32 ± 0.17 | 0.002 ± 0.08 | -0.04 ± 0.22 |
| FA | 0.52 ± 0.18 | -0.10 ± 0.10 | 0.38 ± 0.22 |

[1] RLSV = rear leg side view, RLRV = rear leg rear view, H = hocks, BQ = bone quality and FA = foot angle.

Onyiro & Brotherstone, (2008), Van Dorp *et al.* (2004), Van der Waaij *et al*. (2005) and Boelling, (1997) showed heritabilities, genetic and phenotypic correlation between locomotion and feet and legs type traits in their studies. Onyiro & Brotherstone, (2008) used data from 156 770 Holstein-Friesians in their first lactation, collected from 2000 through 2006. Van der Waaij *et al.* (2005) used data from 4469 Holstein-Friesian cows, collected from May 2002 through October 2003. Van Dorp *et al*, 2004 used data from 3298 Holstein, collected 1997 during the first lactation for type traits and during all the lactation for locomotion and last Boelling, (1997) used data collected from 31 768 cows in their first lactation. The heritability for locomotion was 0.11, 0.10, 0.06 and 0.10 respectively. Correlations between locomotion and feet and leg type traits is presented in Table 13. Note, the linear scale for locomotion ranged from lame to normal in the study by Onyiro & Brotherstone, (2008) and Van deer Waaij *et al.* (2005) whereas normal to lame in the study by Van Dorp *et al.* (2004) and Boelling, (1997).

***Table 13.*** Genetic ( $r_g$ ) and phenotypic ( $r_p$ ) correlations between locomotion and type traits (from Onyiro & Brotherstone, 2008; Van der Waaij *et al.*, 2005; Van Dorp *et al.*, 2004)

| Trait[1] | $r_g$ | $r_p$ | Source |
|---|---|---|---|
| | -0.26 (±0.099) | -0.16 (±0.006) | Onyiro & Brotherstone, 2008 |
| RLSV | -0.14 (±0.20) | -0.20 (±0.01) | Van der Waaij *et al.*, 2005 |
| | 0.81* | 0.09 | Van Dorp *et al*, 2004 |
| | 0.33 (0.15-0.19) | 0.22 (±0.01) | Boelling, 1997 |
| RLRV | 0.70 (±0.14) | 0.51 (±0.01) | Van der Waaij et al., 2005 |
| BQ | -0.26* | -0.04 | Van Dorp *et al*, 2004 |
| | 0.30 (±0.099) | 0.20 (±0.005) | Onyiro & Brotherstone, 2008 |
| FA | 0.47 (±0.18) | 0.32 (±0.01) | Van der Waaij et al., 2005 |
| | -0.84* | -0.07 | Van Dorp *et al*, 2004 |
| | -0.58 (0.15-0.19) | -0.21 (±0.01) | Boelling, 1997 |

* Significant genetic correlations.

[1] RLSV = rear leg side view, RLRV = rear leg rear view, BQ = bone quality and FA = foot angle.

A trend was found where the estimated correlations between RLRV and locomotion showed strongest correlations (Boelling *et al.,* 2007 & Van der Waaij *et al*., 2005). Boelling *et al.,* 2005 did also show generally stronger correlations among type traits and locomotion for Red Danish than Holstein and Jersey in their study. The correlations between type traits and locomotion generally ranged from low to high.

## MATERIAL AND METHODS

All feet and legs type trait data, claw trimming data and pedigree records were provided from the Swedish Dairy Association.

### Type traits data set

Rear leg side view (RLSV), rear leg rear view (RLRV), hock quality (HQ), bone structure (BS) and foot angle (FA) for Swedish Holstein (SH) and Swedish Red (SR) cows were included in this study. The original data set for type traits contained records from 270 895 cows in their first lactation, collected from August 1992 through October 2007. Of these, 130 769 were SH, 137 555 were SR and 2571 were cows from other breeds.

The original data file was edited with SAS (1999), to obtain appropriate data sets for the statistic analysis. Cows with type trait records before July 2000 and after June 2007 were excluded from this study. Too few records were collected before July 2000 to make them trustworthy and records after June 2007 were excluded because records of year 2007 were incomplete. Figure 3 shows the number of classifications for the two breeds with type traits data over years. After editing, the two data sets contained 99 835 and 104 227 type trait records for SH and SR, respectively.

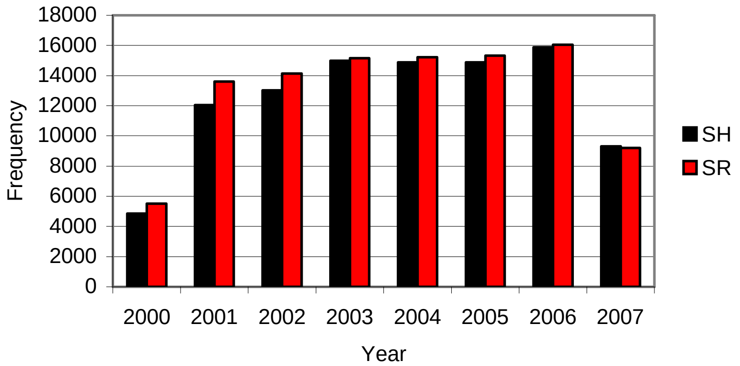



***Figure 3.*** Number of type trait classification records per year for Swedish Holstein (SH) and Swedish Red (SR).

Figure 4 shows the distribution of number of classifications per month for the two breeds. As seen, a similar trend for SH and SR was found, with a high number of observations in spring and in fall.

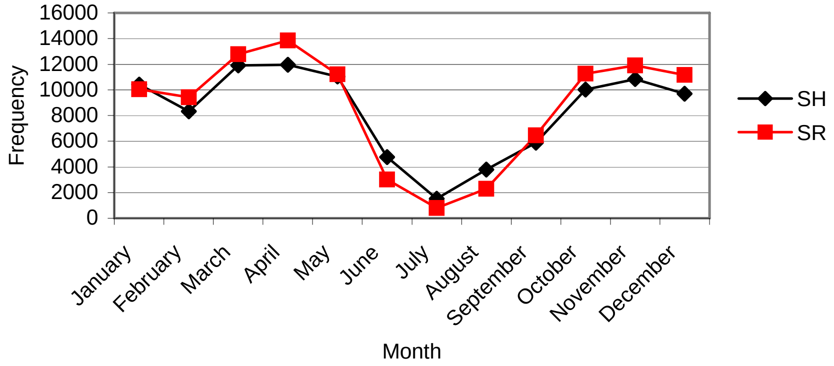



***Figure 4***. Number of type trait classification records per month for Swedish Holstein (SH) and Swedish Red (SR).

Figures 5 and 6 show the distribution of scores among the type traits for Swedish Holstein and Swedish Red, while Table 14 show a more detailed presentation of the means and SD for the two breeds. A similar trend was found for the distribution of scores for type traits of the two breeds.

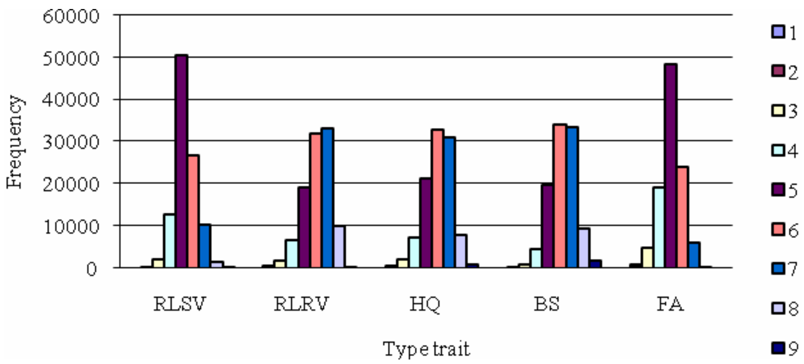



***Figure 5***. Distribution of scores for the type traits; rear leg side view (RLSV), rear leg rear view (RLRV), hock quality (HQ), bone structure (BS) and foot angle (FA) for **Swedish Holstein.**

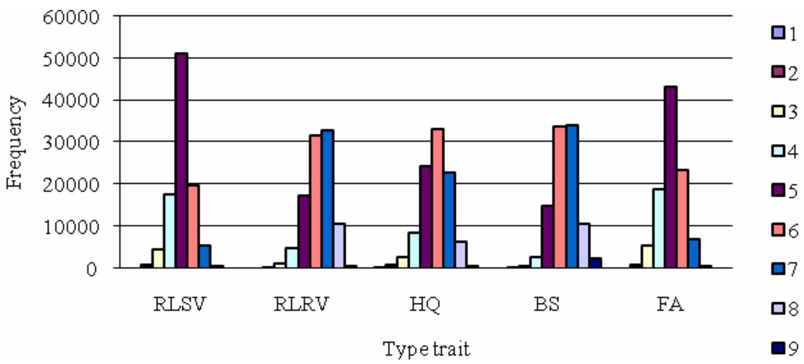



***Figure 6***. Distribution of scores for the type traits; rear leg side view (RLSV), rear leg rear view (RLRV), hock quality (HQ), bone structure (BS) and foot angle (FA) for **Swedish Red.**

***Table 14.*** Means and SD among the five type traits for **Swedish Holstein** and **Swedish Red**

| | SH | | SR | |
|---|---|---|---|---|
| Trait[1] | Mean | SD | Mean | SD |
| RLSV | 5.03 | 0.95 | 5.34 | 0.95 |
| RLRV | 6.24 | 1.13 | 6.14 | 1.19 |
| HQ | 5.83 | 1.25 | 6.04 | 1.21 |
| BS | 6.39 | 1.09 | 6.24 | 1.13 |
| FA | 5.06 | 1.04 | 5.05 | 0.99 |

[1] RLSV = rear leg side view, RLRV = rear leg rear view, HQ = hock quality and FA = foot angle.

The frequency distribution for the five type traits; rear leg side view (RLSV), rear leg rear view (RLRV), hock quality (HQ), bone structure (BS) and foot angle (FA) were in a similar range for SH and SR (Figure 5, 6 and Table 14). Rear leg side view, hock quality and foot angle were in accordance with the optimum scores that are used in NAV (Table 1) while the optimum scores used in NAV for rear leg rear view and bone structure were higher than the estimated scores for both breeds.

### Claw trimming data set

The claw trimming data included records from four claw disorders; dermatitis (DD), heel horn erosion (HE), sole haemorrhage (SH) and sole ulcer (SU). The records included 65 789 SH and 58 457 SR, collected from 2003 through 2007. According to the time limit only records from the first trimming in the first lactation were included in this study. Table 15 shows the distribution of scores for claw disorders.

***Table 15.*** Different scores in percent for dermatitis, heel horn erosion, sole haemorrhage and sole ulcer for Swedish Holstein and Swedish Red. Score 0 (free from lesion), score 1 (mild lesion) and score 2 (severe lesion).

| | SH | | | SR | | |
|---|---|---|---|---|---|---|
| Disorders | 0 | 1 | 2 | 0 | 1 | 2 |
| Dermatitis | 92.52 | 5.99 | 1.49 | 93.32 | 5.61 | 1.06 |
| Heel horn erosion | 84.96 | 12.78 | 2.26 | 82.32 | 15.00 | 2.67 |
| Sole heamorrhage | 72.21 | 19.40 | 8.39 | 74.94 | 17.21 | 7.84 |
| Sule ulcer | 94.73 | 3.28 | 1.99 | 96.15 | 2.47 | 1.38 |

Differences in frequency between the four diseases were found. Sole ulcer had the lowest prevalence (~4.5%) followed by dermatitis (~7%), heel horn erosion (~15-17.5%) and sole haemorrhage with the highest prevalence of ~25-28%. The prevalence were in similar range for SH and SR. Since there are no environmental related information in the raw data for this study, it is not possible to find a trend e.g. if the prevalence of feet and leg problem were higher in cubicles than tied stall. This is, however, an interesting future research area.

### Joint data set

To estimate correlations between type traits and claw lesions the two data files, claw trimming data set and type trait data set, were merged together and the joint data set included 144 898 SH and 142 647 SR.

## Pedigree data set

Pedigrees were traced separately for cows with claw trimming data (269 555 SH and 274 059 SR) and cows with type trait data (339 960 SH and 382 586 SR) and then merged together to a breed wise joint pedigree data set for cows with either or both claw trimming data and type trait data. Genetic analyses were made breed wise and, therefore, only pedigrees from the breed in the specific analyses were included.

## Statistical models

The variance and covariance components, in this study, were estimated with the DMU package, version 6 (Madsen & Jensen, 2007). The two following animal models were used and combined to estimate correlations between type traits and claw disorders.

The model to estimate variance and covariance among type traits was:

$$Y_{ijklmn} = calvage_i + lactsta_j + classmonth_k + year{*}season_l + cow_m + e_{ijklm} \qquad (1)$$

Where $Y_{jklmn}$ = Type trait observation; $calvage_i$ = fixed effect of age at first calving in months, i = 20,..,36; $lactsta_j$ = fixed effect of lactation stage. j = 1,..,8; $classmonth_k$ = fixed effect of month of classification, k = 1,..,12; $year{*}season_l$ = fixed effect, where season goes from first July one year to last June the next year; $cow_m$ = random effect of cow, ~ND(0, $\mathbf{A}\sigma^2_{a(tt)}$); $e_{ijklmn}$ = random residual, ~ND(0, $\sigma^2_E$)

June and July were set as limits when year*season goes from first of July one year to last of June the next year. Year*season includes either herd*year*season (≥3 observations) or classifier*year*season (<3 observations), this to not loose any data.

The model for claw disorders was:

$$Y_{ijklmn} = lactst_i + calvage_j + calvmonth_k + training_l + herd\text{-}year_m + cow_n + e_{ijklmn} \qquad (2)$$

Where $Y_{ijklm}$ = claw trimming observation; $lactst_i$ = fixed effect of stage of lactation in months at time of claw trimming, i=1,..,18; $calvage_j$ = fixed effect of calving age in months, j=20,..,36; $calvmonth_k$ = fixed effect of month of calving;
$Training_l$ = fixed effect of training of claw trimmer, l=1,..,4; $herd\text{-}year_m$ = random effect – herd * year, year goes from July one year to June the next, ~ND(0, $\sigma^2_{hy}$); $cow_n$ = random effect of cow, ~ND(0, $\mathbf{A}\sigma^2_A$); $e_{ijklm}$ = random residual. ~ND(0, $\sigma^2_E$)

Heritabilites were estimated as $h^2 = \sigma^2_A / (\sigma^2_A + \sigma^2_E)$, where $\sigma^2_A$ is the additive genetic variance and $\sigma^2_E$ is the residual variance.

**Model in matrix form**

Model (3) is an animal model that was used to estimate correlations between claw disorders and type traits. $\mathbf{y_{tt}}$ and $\mathbf{y_{cd}}$ were vectors of observations of cows with scores for type traits (*tt*) and for claw disorders (*cd*). The cows that were used in this study were in their first lactation. The matrix for $\mathbf{X_{tt}}$, $\mathbf{X_{cd}}$, $\mathbf{Z_{tt}}$, $\mathbf{Z_{cd}}$, $\mathbf{W_{tt}}$ and $\mathbf{W_{cd}}$ were the corresponding incidence matrices while $\mathbf{b_{tt}}$ and $\mathbf{b_{cd}}$ were fixed effects and $\mathbf{u_{tt}}$, $\mathbf{u_{cd}}$ were random additive genetic effect of the cow. $\mathbf{h_{cd}}$ was the vector for random effect of herd and $\mathbf{e_{tt}}$ and $\mathbf{e_{cd}}$ were random residuals.

$$\begin{bmatrix} \mathbf{y}_{tt} \\ \mathbf{y}_{cd} \end{bmatrix} = \begin{bmatrix} \mathbf{X}_{tt} & 0 \\ 0 & \mathbf{X}_{cd} \end{bmatrix} \begin{bmatrix} \mathbf{b}_{tt} \\ \mathbf{b}_{cd} \end{bmatrix} + \begin{bmatrix} \mathbf{Z}_{tt} & 0 \\ 0 & \mathbf{Z}_{cd} \end{bmatrix} \begin{bmatrix} \mathbf{u}_{tt} \\ \mathbf{u}_{cd} \end{bmatrix} + \begin{bmatrix} \mathbf{W}_{tt} & 0 \\ 0 & \mathbf{W}_{d} \end{bmatrix} \begin{bmatrix} 0 \\ \mathbf{h}_{cd} \end{bmatrix} + \begin{bmatrix} \mathbf{e}_{tt} \\ \mathbf{e}_{cd} \end{bmatrix} \qquad (3)$$

where

$$\mathbf{Var}\begin{bmatrix} \mathrm{u}_{tt} \\ \mathrm{u}_{cd} \end{bmatrix} = \mathbf{G}_0 \otimes \mathbf{A}$$

$\mathbf{G_0}$ is a matrix of genetic(co)variances and $\mathbf{A}$ is the relationship matrix.

$$\mathbf{G}_0 = \begin{bmatrix} \sigma^2_{a(tt)} & \sigma_{a(tt),a(cd)} \\ \sigma_{a(cd),a(tt)} & \sigma^2_{a(cd)} \end{bmatrix}$$

where

$$\mathbf{var}\begin{bmatrix} \mathbf{e}_{tt} \\ \mathbf{e}_{cd} \end{bmatrix} = \mathbf{R}_0 \otimes \mathbf{I_N}$$

$$\mathbf{var}\begin{bmatrix} \mathbf{0} \\ \mathbf{h}_{cd} \end{bmatrix} = \mathbf{H}_0 \otimes \mathbf{I_N}$$

$$\mathbf{H}_0 = \begin{bmatrix} \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \boldsymbol{\sigma}^{\mathbf{2}}_{h(cd)} \end{bmatrix}$$

$\mathbf{R_0}$ is a matrix of residual(co)variances and $\mathbf{I_N}$ is the identity matrix of size N.

$$\mathbf{R}_0 = \begin{bmatrix} \sigma^2_{e(tt)} & \sigma_{e_{tt,cd}} \\ \sigma_{e_{cd,tt}} & \sigma^2_{e(cd)} \end{bmatrix}$$

## RESULTS AND DISCUSSION

### Heritabilities and correlations for type traits

The heritabilities for the five type traits for the Swedish Holstein (SH) and Swedish Red (SR) are shown in Figure 7, with a more detailed presentation in Table 16 for SH and Table 17 for SR.

There were slightly higher heritiabilities for SR than SH with a range between 0.11-0.23 for SH and 0.10-0.31 for SR (Figure 7). These heritabilites were similar to other international studies (Van der Waaij *et al.*, 2006; Van Dorp *et al.*, 2005 & 1997; Pérez- Cabal *et al.*, 2002 & 2006) and to those used in NAV (Principles of Danish Cattle Breeding, 2006).

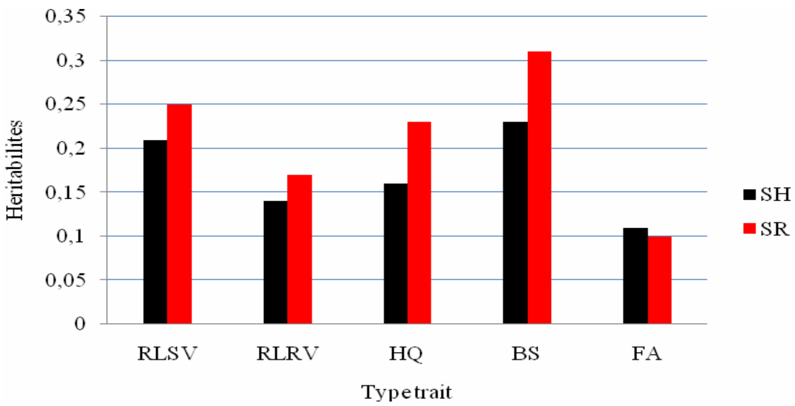



***Figure 7.*** Heritabilites for rear leg side view (RLSV), rear leg rear view (RLRV), hock quality (HQ), bone structure (BS) and foot angle (FA) for SH and SR, respectively.

Correlations between type traits (Table 16 and 17) for both SH and SR were low, which is in accordance to other studies (Van der Waaij *et al.*, 2005; Boelling, 1997; Boelling *et al.*, 2001), with exception of the estimated correlation between hock quality and bone structure that had very high correlations (0.87 for SH and 0.92 for SR). These high correlations agree with genetic correlations (0.70 for Danish Red and 0.78 for Danish Friesian) estimated by Boelling *et al.* (2001). Residual correlations were estimated between type traits but since they were close to zero they are not shown in the tables. As mentioned, the estimated heritabilites and genetic correlations for type traits were similar to other studies, which indicate that Swedish routine for feet and legs type traits classifications and studies based on Swedish type trait data is internationally defendable.

***Table 16.*** Heritabilities (**bold**) and genetic correlations with (SE) among type traits and between claw disorders and type traits for SH

| Trait[1] | RLSV | RLRV | HQ | BS | FA |
|---|---|---|---|---|---|
| DD | *0.13 (0.06)* | 0.12 (0.07) | -0.04 (0.07) | 0.02 (0.06) | *0.15 (0.07)* |
| HE | *0.23 (0.07)* | -0.03 (0.07) | -0.01 (0.07) | 0.07 (0.07) | 0.07 (0.08) |
| SH | 0.18 (0.08) | -0.08 (0.08) | -0.08 (0.08) | -0.02 (0.08) | -0.03 (0.09) |
| SU | *0.28 (0.07)* | 0.16 (0.08) | -0.08 (0.08) | 0.10 (0.07) | -0.03 (0.08) |
| RLSV | **0.21** | -0.06 (0.04) | *0.25 (0.04)* | *0.09 (0.03)* | *-0.39 (0.04)* |
| RLRV | | **0.14** | *0.15 (0.04)* | *0.15 (0.04)* | 0.03 (0.05) |
| HQ | | | **0.16** | *0.87 (0.01)* | -0.07 (0.05) |
| BS | | | | **0.23** | -0.001 (0.04) |
| FA | | | | | **0.11** |

Significant genetic correlations in *italic.*
[1] DD = dermatitis, HE = heel horn erosion, SH = sole haemorrhage, SU = sole ulcer, RLSV = rear leg side view, RLRV = rear leg rear view, HQ = hock quality, BS = bone structure and FA = foot angle.

***Table 17.*** Heritabilities (**bold**) and genetic correlations with (SE) among type traits and between claw disorders and type traits for SR

| Trait[1] | RLSV | RLRV | HQ | BS | FA |
|---|---|---|---|---|---|
| DD | 0.09 (0.08) | 0.09 (0.09) | *-0.19 (0.08)* | -0.23 (0.08) | 0.03 (0.09) |
| HE | *0.17 (0.07)* | -0.11 (0.08) | *-0.31 (0.07)* | *-0.24 (0.07)* | -0.05 (0.09) |
| SH | *0.16 (0.07)* | -0.06 (0.07) | -0.10 (0.07) | *-0.19 (0.06)* | *-0.25 (0.08)* |
| SU | 0.11 (0.08) | 0.14 (0.09) | -0.15 (0.08) | *-0.17 (0.08)* | 0.12 (0.09) |
| RLSV | **0.25** | *-0.22 (0.04)* | -0.02 (0.03) | *-0.12 (0.03)* | *-0.38 (0.04)* |
| RLRV | | **0.17** | *0.18 (0.04)* | *0.10 (0.03)* | *0.18 (0.05)* |
| HQ | | | **0.23** | *0.92 (0.01)* | *-0.11 (0.04)* |
| BS | | | | **0.31** | -0.08 (0.04) |
| FA | | | | | **0.10** |

Significant genetic correlations in *italic.*
[1] DD = dermatitis, HE = heel horn erosion, SH = sole haemorrhage, SU = sole ulcer, RLSV = rear leg side view, RLRV = rear leg rear view, HQ = hock quality, BS = bone structure and FA = foot angle.

### Correlations between type traits and claw diseases

Correlations between type traits (rear leg side view, rear leg rear view, hock quality, bone structure and foot angle) and claw disorders (dermatitis, heel horn erosion, sole haemorrhage and sole ulcer) for SH and SR are shown in Table 16 and 17. The estimated residual correlations (with SE) were, close to zero for both breeds and are not shown in the tables.

All genetic correlations between type traits and claw disorders for SH were low or non-significant, different from zero (Table 16). The strongest correlations were between rear leg side view and claw disorders with a range of 0.13-0.28 between rear leg side view versus dermatitis and rear leg side view versus sole ulcer, while the correlations between hock quality and different claw disorders were negligible. As seen in Table 16, the rest of the correlations (rear leg rear view, foot angle and bone structure to claw disorders) were, like foot angle, non-significant and close to zero except for rear leg rear view versus dermatitis, rear leg rear view versus sole ulcer, foot angle versus dermatitis and bone structure versus sole ulcer, where the estimated correlations were larger than 0.10. Van der Waaij *et al.* (2005) found similar results in their study of Holstein cattle while Koenig *et al.* (2005), on the other hand, showed generally strong correlations for Holstein between type traits and claw disorders.

Table 17 shows the genetic correlations between type traits and claw disorders for SR. The correlations were in general higher for SR than SH, only correlations between rear leg rear view and claw disorders were in similar range (-0.06 to 0.14). No environmental information or other information in the raw data could explain the present breed difference for the genetic correlations. To include environmental information in future studies are, however, an interesting research area. In that way possible breed difference and differences in the same breed may be obtained. The highest correlations for SR were observed between hock quality and different claw disorders (range from –0.10 to -0.31) and between bone structure and different claw disorders (range from –0.17 to –0.24). The remaining correlations (rear leg side view, rear leg rear view and foot angle to claw disorders) were greater than ± 0.10 except for rear leg side view versus dermatitis, rear leg rear view versus dermatitis, rear leg rear view versus sole haemorrhage, foot angle versus dermatitis and foot angle versus heel horn erosion which were lower than ± 0.10. No correlations specific for SR was found in the literature, however, the same trend can be seen for SR as for SH (Van der Waaij *et al.*, 2005; Koenig *et al*., 2005).

Boelling *et al*. (2007) showed that genetic correlations between locomotion and type traits for Red Danish were medium to high (0.32-0.77) while the genetic correlations for Holstein were close to zero, except for a high correlation (0.73) between locomotion and rear leg rear view. In present study the correlations were in general low and only small breed differences were observed.

## CONCLUSION

This is the first time correlations within and between feet and legs type traits and claw health data have been studied in Swedish cows. The correlations and heritabilities for SH and SR were in similar range as in earlier studies (Van der Waaij *et al.*, 2005; Van Dorp *et al.*, 2005 & 1997; Pérez- Cabal *et al.*, 2002 & 2006). This indicates that Swedish classifiers for type traits are well trained, with a well working routine that can be compared with classifiers from other countries. With knowledge of this, more internationally comparably studies based on Swedish type traits data can be made.

The genetic correlations for SH were low or non-significant and close to zero while SR generally showed higher correlations between type traits and claw disorders. The correlations were, however, still low and future indirect selection for better claw health using type traits is not possible for neither SH nor SR. Claw trimming data add valuable information about the health of the claws. Claw trimmers must be encouraged to keep high quality records of claw health to generate data with high reliability to be used in further studies to improve claw health (Appendix 2).

Locomotion has according to a Danish study shown to have a strong relationship to feet and legs type traits. Denmark is the only country in NAV that is estimating locomotion and this is only on a test basis. The strong correlations between locomotion and type traits indicate that indirect selection for better locomotion using type traits might be possible. With knowledge of this, a suggestion for further research is to estimate the correlations between locomotion and claw health using records of locomotion from Denmark and claw health records from Swedish claw trimmers.

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*Emelie Uggla*

Uppsala, May 2008

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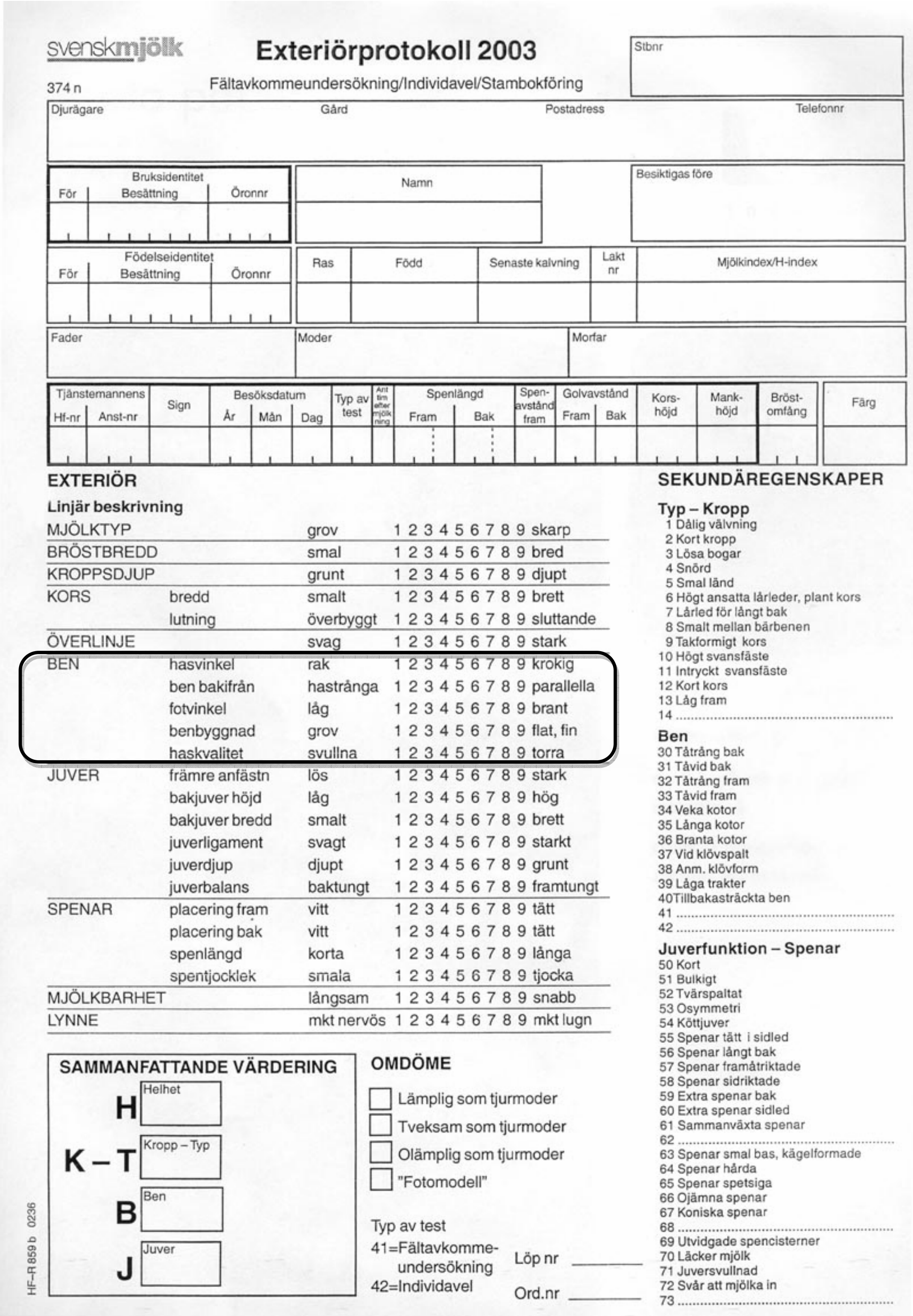
**Appendix 1**



svenskmjölk **Exteriörprotokoll 2003**

374 n Fältavkommeundersökning/Individavel/Stambokföring

Stbnr

| Djurägare | Gård | Postadress | Telefonnr |
|---|---|---|---|
| | | | |

| Bruksidentitet | | | Namn | Besiktigas före |
|---|---|---|---|---|
| För | Besättning | Öronnr | | |
| | | | | |

| Födelseidentitet | | | Ras | Född | Senaste kalvning | Lakt nr | Mjölkindex/H-index |
|---|---|---|---|---|---|---|---|
| För | Besättning | Öronnr | | | | | |
| | | | | | | | |

| Fader | Moder | Morfar |
|---|---|---|
| | | |

| Tjänstemannens | | Sign | Besöksdatum | | | Typ av test | Ant tim efter mjölkning | Spenlängd | | Spen-avstånd | Golvavstånd | | Kors-höjd | Mank-höjd | Bröst-omfång | Färg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hf-nr | Anst-nr | | År | Mån | Dag | | | Fram | Bak | fram | Fram | Bak | | | | |
| | | | | | | | | | | | | | | | | |

**EXTERIÖR**

**Linjär beskrivning**

| | | | | |
|---|---|---|---|---|
| MJÖLKTYP | | grov | 1 2 3 4 5 6 7 8 9 | skarp |
| BRÖSTBREDD | | smal | 1 2 3 4 5 6 7 8 9 | bred |
| KROPPSDJUP | | grunt | 1 2 3 4 5 6 7 8 9 | djupt |
| KORS | bredd | smalt | 1 2 3 4 5 6 7 8 9 | brett |
| | lutning | överbyggt | 1 2 3 4 5 6 7 8 9 | sluttande |
| ÖVERLINJE | | svag | 1 2 3 4 5 6 7 8 9 | stark |
| BEN | hasvinkel | rak | 1 2 3 4 5 6 7 8 9 | krokig |
| | ben bakifrån | hastrånga | 1 2 3 4 5 6 7 8 9 | parallella |
| | fotvinkel | låg | 1 2 3 4 5 6 7 8 9 | brant |
| | benbyggnad | grov | 1 2 3 4 5 6 7 8 9 | flat, fin |
| | haskvalitet | svullna | 1 2 3 4 5 6 7 8 9 | torra |
| JUVER | främre anfästn | lös | 1 2 3 4 5 6 7 8 9 | stark |
| | bakjuver höjd | låg | 1 2 3 4 5 6 7 8 9 | hög |
| | bakjuver bredd | smalt | 1 2 3 4 5 6 7 8 9 | brett |
| | juverligament | svagt | 1 2 3 4 5 6 7 8 9 | starkt |
| | juverdjup | djupt | 1 2 3 4 5 6 7 8 9 | grunt |
| | juverbalans | baktungt | 1 2 3 4 5 6 7 8 9 | framtungt |
| SPENAR | placering fram | vitt | 1 2 3 4 5 6 7 8 9 | tätt |
| | placering bak | vitt | 1 2 3 4 5 6 7 8 9 | tätt |
| | spenlängd | korta | 1 2 3 4 5 6 7 8 9 | långa |
| | spentjocklek | smala | 1 2 3 4 5 6 7 8 9 | tjocka |
| MJÖLKBARHET | | långsam | 1 2 3 4 5 6 7 8 9 | snabb |
| LYNNE | | mkt nervös | 1 2 3 4 5 6 7 8 9 | mkt lugn |

**SAMMANFATTANDE VÄRDERING**

H Helhet

K – T Kropp – Typ

B Ben

J Juver

HF-R 859 b 0236

**OMDÖME**

- ☐ Lämplig som tjurmoder
- ☐ Tveksam som tjurmoder
- ☐ Olämplig som tjurmoder
- ☐ "Fotomodell"

Typ av test
41=Fältavkomme-undersökning
42=Individavel

Löp nr ______

Ord.nr ______

**SEKUNDÄREGENSKAPER**

**Typ – Kropp**
1 Dålig välvning
2 Kort kropp
3 Lösa bogar
4 Snörd
5 Smal länd
6 Högt ansatta lårleder, plant kors
7 Lårled för långt bak
8 Smalt mellan bärbenen
9 Takformigt kors
10 Högt svansfäste
11 Intryckt svansfäste
12 Kort kors
13 Låg fram
14 ..........

**Ben**
30 Tåtrång bak
31 Tåvid bak
32 Tåtrång fram
33 Tåvid fram
34 Veka kotor
35 Långa kotor
36 Branta kotor
37 Vid klövspalt
38 Anm. klövform
39 Låga trakter
40 Tillbakasträckta ben
41 ..........
42 ..........

**Juverfunktion – Spenar**
50 Kort
51 Bulkigt
52 Tvärspaltat
53 Osymmetri
54 Köttjuver
55 Spenar tätt i sidled
56 Spenar långt bak
57 Spenar framåtriktade
58 Spenar sidriktade
59 Extra spenar bak
60 Extra spenar sidled
61 Sammanväxta spenar
62 ..........
63 Spenar smal bas, kägelformade
64 Spenar hårda
65 Spenar spetsiga
66 Ojämna spenar
67 Koniska spenar
68 ..........
69 Utvidgade spencisterner
70 Läcker mjölk
71 Juversvullnad
72 Svår att mjölka in
73 ..........

Feet and leg type traits (ben), rear leg side view (hasvinkel), rear leg rear view (ben bakifrån), foot angle (fotvinkel), bone structure (benbyggnad) and hock quality (bengyggnad)

# Appendix 2

## Codes for the lesions

Most common claw lesions (dermatitis, heel horn erosion, sole haemorrhage and sole ulcer) are scored as mild (/) or severe (X)  No remark in the box if healthy. Lesions scored for cow except for ulcer which is scored for foot.

Dermatitis, digital dermatitis (Exsem)
/ reddnes/ secretion /crusts eschars
X bleeding circular ulceration, painful, DD

Heel horn erosion (Klövröta)
/ shallow erosion of the bulb horn
X extensive deep cracks (to the corium)

Sole haemorrhage (Sulblödning)
/ solitary / shallow hemorrhage
X Extensive several / profound hemorrhage

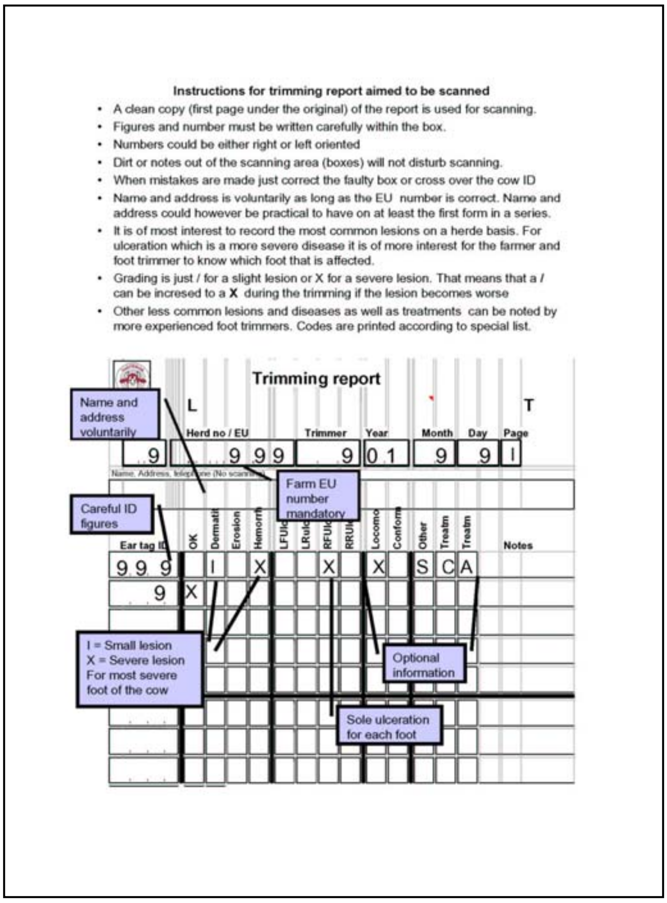
Sole ulcer (VB sår, HB sår, VF sår and HF sår)
/ Ulceration of sole, toe, white line; corium exposed but looks fresh
X Ulceration of sole, toe, white line; affected corium, granulation tissue / necrotic / swollen

Locomotion, lameness (Rörelser, hälta)
/ walking with arched back, stiffness
X standing and walking with arched back lame on one or more feet

Claw shape (Klövform)
A asymmetric, difference in size outer/inner claws
B bear foot, week pastern
S scissors claw, fore claw toes crossed
X overgrown claws, longer than 90 mm
Z corkscrew claws, laterar wall turns inside

Other diseases (Övriga sjukdomar)
A abscess, pus pocket, originating from white line
B lesion of the leg, hock swelling or abscess
D double sole, new sole plus old
F laminitis change of the claw capsule, hard ship groove, concave toe wall
H white line separation
K Interdigital phlegmon, foot rot, foul-in-the-foot
L limax, interdigital hyperplasia, growth of the interdigital space
S sandcrack, horizontal fisurre of the horn wall
T toe abscess, wound / pus / necrosis
V wart (verroucous dermatitis),

Treatment of claws (Behandling 1 and Beh. 2)
A topical antibioticum treatment
B bandage / plaster
C "Cowslip", plastic block
D drainage (open abscess)
E "Easy block", plastic block
K copper sulphate or similarly, locally
O operation, surgery (anaesthesia)
R clean cut of necrotic claw horn
S "Shoof", plastic claw shoe
T wooden block, "Bovi bond"


**Instructions for trimming report aimed to be scanned**

- A clean copy (first page under the original) of the report is used for scanning.
- Figures and number must be written carefully within the box.
- Numbers could be either right or left oriented
- Dirt or notes out of the scanning area (boxes) will not disturb scanning.
- When mistakes are made just correct the faulty box or cross over the cow ID
- Name and address is voluntarily as long as the EU  number is correct. Name and address could however be practical to have on at least the first form in a series.
- It is of most interest to record the most common lesions on a herde basis. For ulceration which is a more severe disease it is of more interest for the farmer and foot trimmer to know which foot that is affected.
- Grading is just / for a slight lesion or X for a severe lesion. That means that a / can be incresed to a **X** during the trimming if the lesion becomes worse
- Other less common lesions and diseases as well as treatments  can be noted by more experienced foot trimmers. Codes are printed according to special list.

| För nr | Besättning / SE nr | Klövvårdare | År | Mån | Dag | Sid |
|---|---|---|---|---|---|---|
| | | | | | | |

Namn, adress, telefon (scannas ej)

| Bruksöronnr | OK | Eksem | Röta | Blödn. | VB sår | HB sår | VF sår | HF sår | Rörel. | Klövf. | Öv.sjk | Beh. 1 | Beh. 2 | Anteckning |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |

L

OK Eksem Röta Blödn. VB sår HB sår VF sår HF sår Rörel. Klövf. Öv.sjk Beh. 1 Beh. 2

Stallsystem

X

**Appendix 3**

# CLAW LESION COLOR ATLAS

**MODERATE/SUPERFICIAL (/) SEVERE/PROFOUND (X)**

## SOLE HAEMORRHAGE

Haemorrhagic discoloration of the sole horn and/or white line. Diffuse symptom of (subclinical) laminitis 2-3 months after calving. Hard floors and intensive unbalanced feeding associated with poor rumination are important risk factors. Normally heals spontaneously but can develop to more severe lesions as ulceration of sole/toe/white line and/or double sole/white line lesions

**Treatment and prevention**

Trimming, balancing the outer and inner claws, and dishing out to unload the ulcer area is recommended. Rubber mats where the cows are walking and standing and optimized cow comfort are measures to prevent and reduce the risk for complications.


## SOLE ULCER

Open wound (ulceration) of the sole, toe or white line often complicated by a deeper infection and or inflammation. Common cause of lameness. The ulcer is caused by compression of the corium between the claw bone and sole. Laminitis and trauma predisposes to or causes ulcers.

**Treatment and prevention**

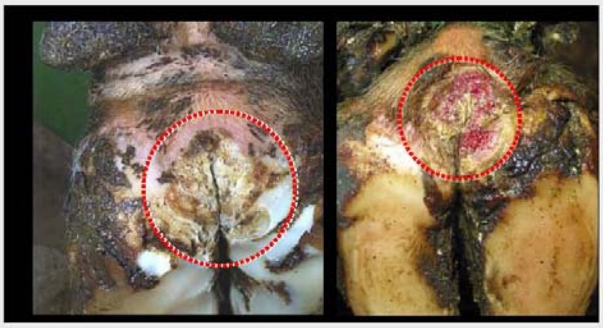
Trimming and balancing of the outer and inner claws and dishing-out of the sole to unload the ulcer area. Blocking of the healthy claw to reduce pain and improve healing. Balanced diets, proper feeding, rubber mats where the cows are walking and standing, and optimized cow comfort prevent the condition.

## DIGITAL DERMATITIS

Inflammation of the digital and/or interdigital skin with ulcerations or crusts. Mild/early stages do not cause lameness and are often neglected if feet are not cleansed. The dermatitis can progress to more severe, painful lesions causing severe lameness. Most often A hygiene related herd problem that can spread from animal to animal and from herd to herd if biosecurity precautions are not undertaken.

**Treatment and prevention**

Mild to moderate dermatitis heals spontaneously with improved hygiene of stalls and feet. Proper foot bathing cleanses and disinfects feet and thus reduces the symptoms and controls spreading.

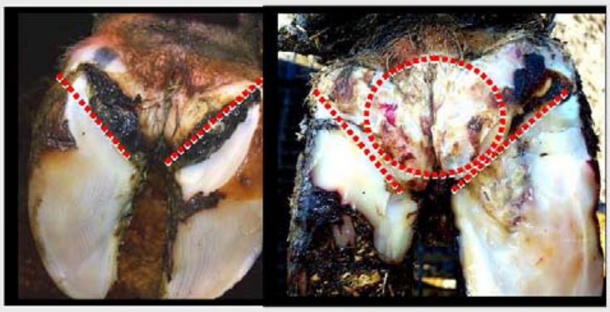


## HEEL HORN EROSION

V-shaped erosions and clefts in the bulbs or circular craters that can undermine the heels. Most often double-sided and more common in the rear feet. Associated with dermatitis. Deeper erosions progressing to the corium may cause lameness.

**Treatment and prevention**

Trimming away diseased horn and treatment of dermatitis with antibacterial compounds locally. Foot bathing can prevent herd problems but most important to improve environment and foot hygiene.



## Appendix 4

Heritabilites with (SE) for type traits among different breeds and by different references

| | Principles of Danish Cattle Breeding, 2006 (NAV run) | Van der Waaij *et al., 2006* | Van Dorp *et al*., 2005 | Van Dorp *et al*., 1997 | Pérez- Cabal *et al*., 2002 | Pérez- Cabal *et al*., 2006 | Boelling, 1997 |
|---|---|---|---|---|---|---|---|
| Trait[1]/ breed | Holstein & Ayrshire | Holstein-Fresian | Holstein | Holstein | Spanish Holstein | Spanish Holstein | Holstein |
| RLSV | 0.23 | 0.22 (0.04) | 0.23 | 0.16 | 0.17 (0.01) | 0.12 (0.007) | 0.19 (0.03-0.05) |
| RLRV | 0.19 | 0.11 (0.03) | | | | | |
| HQ | 0.18 | | | | | | |
| BQ | | | 0.30 | 0.20 | | | |
| BS | 0.28 | | | | | | |
| FA | 0.18 | 0.18 (0.03) | 0.10 | 0.15 | 0.11 (0.01) | 0.19 (0.008) | 0.11 (0.03-0.05) |

| | Lawstuen *et al*., 1986 | Boelling et al., 2001 | | | Boelling et al., 2007 | | | Vukasinovic *et al.*, 2002 |
|---|---|---|---|---|---|---|---|---|
| Trait[1]/ breed | Holstein | Danish Red | Danish Friesian | Jersey | Danish Red | Holstein | Jersey | Swiss Simmental & Red & white Cattle |
| RLSV | 0.16 (0.02) | 0.24 (0.02) | 0.24 (0.01) | 0.15 (0.01-0.02) | 0.13 | 0.17 | 0.16 | 0.27 |
| RLRV | | 0.18 (0.02) | 0.17 (0.01) | 0.09 (0.01-0.02) | 0.13 | 0.12 | 0.10 | 0.21 |
| HQ | | 0.26 (0.02) | 0.19 (0.01) | 0.13 (0.01-0.02) | | | | 0.29 |
| H | | | | | 0.23 | 0.17 | 0.19 | |
| BQ | | | | | 0.18 | 0.24 | 0.16 | |
| BS | | 0.32 (0.02) | 0.27 (0.01) | 0.19 (0.01-0.02) | | | | |
| FA | 0.11 (0.02) | 0.15 (0.02) | 0.13 (0.01) | 0.11 (0.01-0.02) | 0.13 | 0.12 | 0.11 | 0.22 |

[1] RLSV = rear leg side view, RLRV = rear leg rear view, HQ = hock quality, H = hocks, BQ = bone quality, BS = bone structure and FA = foot angle.

| Trait[1] | Breed | Genger *et al.*, 1999 | Wiggans *et al.*, 2004 | Wiggans *et al*., 2006 |
|---|---|---|---|---|
| RLSV | Ayrshire | 0.10 | 0.15 | |
| | Brown Swiss | 0.14 | 0.18 | 0.009 |
| | Guernsey | 0.18 | 0.16 | 0.151 |
| | Jersey | 0.10 | 0.07 | |
| | Milking shorthorn | 0.09 | 0.11 | |
| RLRV | Ayrshire | | | |
| | Brown Swiss | | | 0.102 |
| | Guernsey | | | 0.078 |
| | Jersey | | | |
| | Milking shorthorn | | | |
| FA | Ayrshire | 0.12 | 0.15 | |
| | Brown Swiss | 0.08 | 0.13 | 0.119 |
| | Guernsey | 0.11 | 0.10 | 0.085 |
| | Jersey | 0.10 | 0.11 | |
| | Milking shorthorn | 0.09 | 0.09 | |

[1] RLSV = rear leg side view, RLRV = rear leg rear view and FA = foot angle.