# Locomotion as a New Trait: First Results from Denmark

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## Introduction

Lameness has been identified as one of the most prominent disease complexes in cattle, causing welfare implications and considerable economic losses, and has therefore been under research for the last two decades. Locomotion – the way the cow moves forward – has been one of the traits which has received considerable attention. Compared to claw diseases, horn cell characteristics or pressure distribution, the trait is relatively easy to measure visually and is in line with other body conformation traits. When data are collected by field officers, a vast amount of data can be collected in a short time. Different scoring systems have been used, they have in common that they describe locomotion on a scale with several categories from complete lameness to perfect movement. Several countries have taken this trait up as an additional type trait to be assessed by field officers during their routine classification. In the UK, the trait has been part of the official type assessment for more than a decade; in other countries, it has been collected and genetically analysed on a research basis (e.g. Boettcher et al., 1998, van der Waaij et al., 2005). Denmark also introduced Locomotion as a research trait. Data collection started in 2004, by now the data set is large enough in order to estimate genetic parameters within breeds with an adequate reliability, and to draw some conclusions.

## Material and Methods

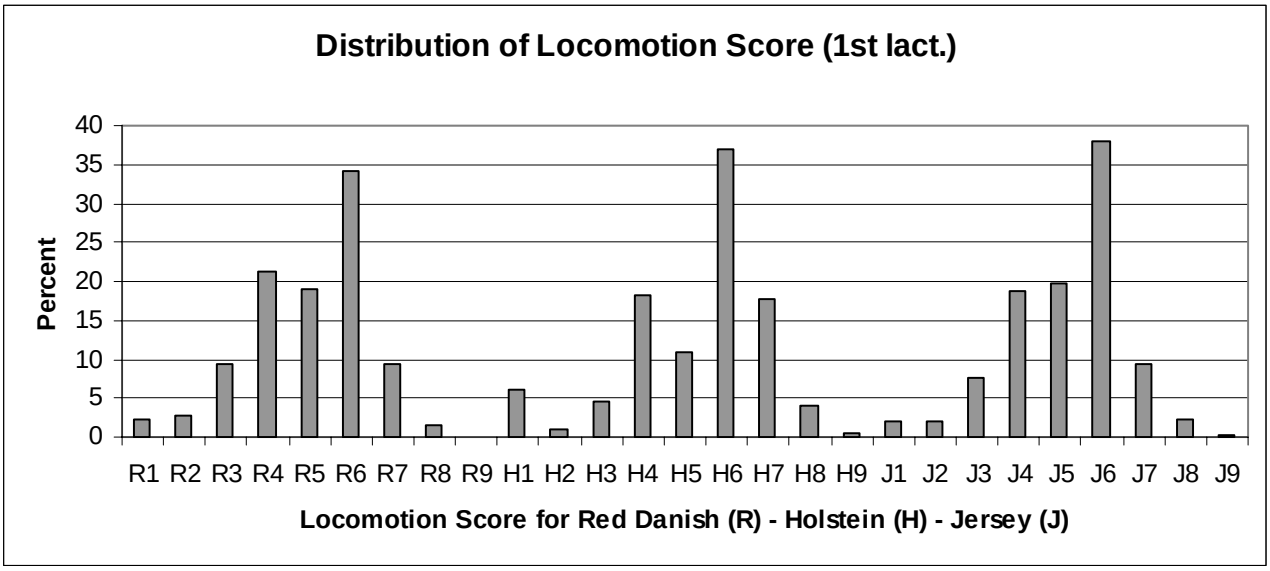
The data set included all records collected between August 2004 and March 2007. Only first lactation records were included in the data. Analyses were separately performed for the three Danish breeds Red Danish, Holstein, and Jersey. Numbers of records are shown in Table 1. The final data sets contained only records with an observation for both Locomotion and type traits.

**Table 1. Number of records per breed and either linear type traits or Locomotion score, and the percentage of Locomotion records in relation to linear records**

| | Linear Type Traits | Locomotion Score | % |
|---|---|---|---|
| Red Danish | 28320 | 6307 | 22.3 |
| Holstein | 150823 | 56470 | 36.9 |
| Jersey | 28109 | 7196 | 25.6 |
| On average | | | 34.9 |

The Locomotion Scoring System which was used in Denmark consisted of nine categories, from clinically lame to perfect locomotion. Figure 1 shows the distribution of the locomotion scores separately for each breed. The first category denoted animals which were clinically lame on the day of scoring. Around six percent of all classifications of Holstein and two percent of either Red Danish or Jersey fell into this category. These observations were excluded from the data set for further analyses. The remaining eight categories describe locomotion from very bad to very good and a normal distribution would be expected. Figure 1 revealed that the trait was normally distributed with the exception of category 5, especially in Holstein.

**Figure 1. Use of categories for Locomotion Score, 1st lactation records**




Definition of Locomotion Scores: 1 = lame; 2 = very severe ab-/adduction, short strides, very uneven gait; 3 = severe ab-/adduction, short strides, uneven gait; 4 = severe ab-/adduction, medium strides, uneven gait; 5 = no ab-/adduction, short strides, even gait; 6= slight ab-/adduction, medium strides, even gait; 7 = slight ab-/adduction, medium strides, even gait; 8 = no ab-/adduction, medium strides, free and even gait; 9 = no ab-/adduction, long strides, free and even gait

The following model which corresponds to that also used for type traits, was applied:

$$y_{ijklmnop} = Age_i + MC_j + SL_k + IYM_l + H_m + R_n + animal_o + e_{ijklmnop}$$

Where $Y_{ijklmnopq}$ is the observation of the respective Locomotion score or confirmation trait. The fixed effect comprised: $Age_i$ as the age at calving in months (i = 20-35), $MC_j$ the month of calving (j = 1-12), $SL_k$ the stage of lactation in months (k = 1-14), $IYM_l$ an inspector-year-month effect, $H_m$ the herd in six months classes, $R_n$ a region-year effect. $Animal_o$ is the random genetic effect and $e_{ijklmnop}$ the residual.
The package DMU (Madsen et al., 2003) was used for the calculation of genetic parameters. The analyses were performed with an animal model, with the exception of the bivariate analyses for Holstein which were run with a sire model due to computing restrictions. The pedigree was traced five generations back.

**Results**
Heritabilities were calculated for Locomotion and the other five Feet & Legs traits which are routinely assessed in Denmark (Table 2). Heritabilities for the F&L traits were comparable for those previously computed on a much bigger data material (Aarsstatistik 2006-2007). Heritability for Locomotion was 0.10, 0.07, and 0.05 for Red Danish, Holstein, and Jersey, respectively.

**Table 2. Heritabilities for F&L traits and Locomotion for Red Danish, Holstein, and Jersey**

| Trait | Red Danish | Holstein | Jersey |
|---|---|---|---|
| Rear Leg Side View | 0.13 | 0.17 | 0.16 |
| Rear Leg Rear View | 0.13 | 0.12 | 0.10 |
| Hocks | 0.23 | 0.17 | 0.19 |
| Bone Quality | 0.18 | 0.24 | 0.16 |
| Foot Angle | 0.13 | 0.12 | 0.11 |
| Locomotion | 0.10 | 0.07 | 0.05 |

Genetic correlations between Locomotion and type traits are shown in Table 3. All F&L traits are presented, while for all body traits routinely assessed in Denmark, only Top Line showed a significant relationship with Locomotion and was therefore the only trait included in the table. In Red Danish, where genes from other breeds like Holstein, American Brown Swiss and Swedish Red and White have been imported, straighter rear legs as seen from the side, straight rear legs as seen from behind, dry hocks, and a steep foot angle were significantly associated with Locomotion. In Holstein and Jersey, only Rear Leg Rear View and Top Line were significantly correlated with Locomotion. Genetic correlations to other body conformation traits which were found in other countries on a smaller data material (Van Dorp et al., 2004) could not be confirmed in this study.

**Table 3. Genetic correlation (+ s.e.) of Locomotion with linear type traits**

| Trait | Red Danish | Holstein | Jersey |
|---|---|---|---|
| Rear Leg Side View | **-0.77** ± 0.12 | 0.03 ± 0.09 | 0.11 ± 0.23 |
| Rear Leg Rear View | **0.81** ± 0.10 | **0.73** ± 0.06 | **0.47** ± 0.20 |
| Hocks | **0.41** ± 0.15 | 0.11 ± 0.09 | -0.11 ± 0.22 |
| Bone Quality | 0.32 ± 0.17 | 0.002 ± 0.08 | -0.04 ± 0.22 |
| Foot Angle | **0.52** ± 0.18 | -0.10 ± 0.10 | 0.38 ± 0.22 |
| Top Line | 0.27 ± 0.19 | **-0.22** ± 0.08 | **-0.56** ± 0.18 |

Data were collected on young modern dairy cows in their first lactation. They should be able to move the rear legs forward in a straight and even way. If they do not, you could argue, then these animals are impaired not because of their high age or poor body structure, but because of a disease. When following this argumentation, the Locomotion Scoring System could be restructured either into a system with two categories (lame (class 1) versus not-lame (classes 2 – 9)) or with three categories (lame (class 1) – subclinically lame (class 2-4) – normal (class 5-9)). Heritabilities for these revised traits are shown in Table 4.

**Table 4. Heritabilities for different Locomotion Systems**

| | Red Danish | Holstein | Jersey |
|---|---|---|---|
| Feet&Leg diseases* | 0.01 | 0.01 | - |
| Lameness 0 – 1 | 0.01 | 0.01 | 0.01 |
| Lameness 0 – 1 – 2 | 0.05 | 0.04 | 0.06 |
| Locomotion | 0.10 | 0.07 | 0.05 |

* Aarsstatistik 2006-2007

The heritability for Lameness 0-1 was 0.01 across breeds and therewith in the same range as Feet&Leg diseases. Mobility scored in three categories yielded a heritability of around 0.04 to 0.06. For Jersey, it was actually higher than that for Locomotion Score.

## Discussion

Currently, Locomotion is included into the classification scheme as a research trait and assessment is not obligatory. Usually, the field officers assess the trait whenever feasible, i.e. when the cow has the possibility to walk a few meters in front of the field officer on a non-slippery surface without disturbance. This is only possible for about one third of all classifications. It would be desirable to obtain more Locomotion records, but the practical implications make it problematical.

Denmark has three main dairy populations, Red Danish, Holstein, and Jersey. Data collection is the same across breeds, but data are analysed separately, which allows a direct comparison between breeds.

As with many traits, the heritability of Locomotion varied across breeds. It was lowest in Jersey which are said to have the least feet and leg problems. For Red Danish and Holstein, it fluctuated between 0.07 and 0.10 which rendered it as the lowest trait among the type classification traits, but higher than some other traits included in the Danish total index, like fertility, some calving traits or diseases (Aarsstatistik). Feet and Leg diseases showed a heritability of 0.01.

A significant genetic correlation between Rear Leg Rear View and Locomotion could be found in all three breeds. Correlations were high, between 0.47 in Jersey and 0.81 in Red Danish, but the traits were still genetically different. Similar high relationships were found in other countries (e.g. Boettcher and Dekkers, 1997).

One lameness scoring system developed by/for veterinarians is based on the bend of the back of a cow. A healthy cow walks with a straight back, while a lame cow walks with an arched back. The negative correlation between Locomotion and Top Line demonstrates just that favourable relationship, i.e. bad locomotion is associated with an arched back.

So far, we have looked upon Locomotion as a possible supplementary linear feet and leg trait. But it might likewise be seen as an alternative trait for diseases. In Denmark, veterinary treatments are recorded in a common data base on national level. Presently, a Master student examines the relationships between feet and leg diseases and Locomotion.

## Conclusion

The three breeds behave differently. Jersey has the least amount of lame cows, and genetic correlations and heritability are lowest. Red Danish showed several significant genetic correlations between Locomotion and feet and leg traits, and the highest heritability. Holstein lay between these two breeds. Only the genetic correlation between Rear Leg Rear View and Locomotion was significant for all breeds.

Locomotion is a new trait which is not fully explained by other feet and leg traits. Due to its nature – the cow has to walk freely on a non-slippery surface – scoring is difficult in Denmark and complete coverage will not be reached in the near future.

It is recommended to await the results of the study on genetic correlations between Locomotion and diseases, before further decisions are taken.

## References

Boettcher, P.J., Dekkers, J.C.M., Warnick, L.D., Wells, S.J., 1998. Genetic analysis of clinical lameness in dairy cattle, J. Dairy Sci. 81, 1148-1156.

Madsen, P., Jensen, J., 2003. A User's Guide to DMU, Version 6, Release 4.4, DIAS, Denmark

NN, 2006. Aarsstatistik Avl 2006-2007, Dansk Kvaeg

Van der Waaij, E.H., Holzhauer, M., Ellen, E., Kamphuis, C., Jong, G. de, 2005. Genetic parameters for claw disorders in Dutch dairy cattle and correlations with conformation traits, J. Dairy Sci. 88, 3672-3678.

Van Dorp, T.E., Boettcher, P.J., Schaeffer, L.R., 2004. Genetics of locomtion, Livest. Prod. Sci. 90, 247-253.