

Comparative Aspects on Genetics of Stillbirth and Calving Difficulty in Swedish Dairy Cattle Breeds

Lena Steinbock

*Faculty of Veterinary Medicine and Animal Science
Department of Animal Breeding and Genetics
Uppsala*

**Licentiate thesis
Swedish University of Agricultural Sciences
Uppsala 2006**

ISBN 91-576-7151-6
© 2006 Lena Steinbock, Uppsala
Tryck: SLU Service/Repro, Uppsala 2006

Abstract

Steinbock, L. 2006. Comparative Aspects on Genetics of Stillbirth and Calving Difficulty in Swedish Dairy Cattle Breeds. Licentiate thesis
ISBN 91-576-7151-6

The stillbirth rate in first-calvers in the Swedish Holstein (SLB) dairy cattle population has increased. At later calvings in SLB, and in the other main Swedish dairy breed, the Swedish Red and White (SRB), by contrast, there has been little change in stillbirth rates over the last two decades. The overall objective of this study was to investigate and compare genetic variation in the calving traits of these two breeds, and to propose improved methods by which to select for a reduction in calving problems.

The SLB heritabilities were 3-6% for stillbirth and calving difficulty at first calving. At second calving they fell to below 1%. In SRB the heritabilities were lower, at 0.5-2%, and the difference between first and second calvings was less pronounced. The heritabilities for direct effect were always slightly higher than those for maternal effect. Genetic correlations between direct and maternal effects were in all cases close to zero. In SLB a large variation (3-16%) was observed in the stillbirth rate of sires and maternal grandsires. Approximately half the genetic variation in stillbirths remained after adjusting for calving difficulty. In SLB the genetic correlations between parities for stillbirth and calving difficulty were medium-high (0.4-0.5). Thus stillbirth and calving difficulty at first calving cannot be considered the same traits in heifers and cows. In SRB the genetic correlations between first- and second-calving results were high (0.7-0.8). Here, therefore, stillbirth and calving difficulty are determined to a much greater extent by the same factors and genes at first and later calvings. Thus although the two breeds differ genetically from each other at first calving, at second calving there are no obvious differences.

In both breeds bulls should be evaluated both as sires and maternal grandsires, and both stillbirth and calving difficulty should be included in the genetic evaluations. In SLB it is unlikely that the accuracy of a bull's estimated transmitting ability (ETA) can be increased by including information from second calving. In SRB, on the other hand, the accuracy of breeding values will be considerably improved by using information from both calvings. A bivariate or a repeatability model would be equally appropriate here.

In the SLB study we concluded that heritabilities from linear analyses adjusted from the visible to the underlying scale corresponded well with those directly estimated by threshold models. For SRB, threshold analyses were unsuccessful as a result of the low incidences and low heritabilities in the calving traits. At present, therefore, there is no reason for using a more time-consuming method that also is very sensitive to the structure of the data.

The studies reported here indicate that heifers of both breeds should be at least 24 months at calving, as this will minimise the rates of stillbirth and calving problems. For the same reason, it would be advantageous to encourage calvings in late summer or early autumn.

Keywords: stillbirth, calving difficulty, dairy cattle, genetic parameters, correlations between parities, calving age, linear and threshold models

Author's address: Lena Steinbock, Department of Animal Breeding and Genetics, Box 7023, Swedish University of Agricultural Sciences, SE-750 07 Uppsala, Sweden. Email: Lena.Steinbock@hgen.slu.se

Contents

Introduction, 7

Background, 8

Importance of stillbirth and calving difficulty, 8

Recording and definition of traits, 9

Direct and maternal traits, 9

Birth weight and gestation length as related traits, 11

Genetic parameters and evaluations, 11

Objectives of the thesis, 12

Summary of investigations presented, 12

I. Genetic effects on stillbirth and calving difficulty in Swedish Holsteins at first and second calving, 13

II. Genetic effects on stillbirth and calving difficulty in Swedish Red and White dairy cattle at first and second calving, 13

General discussion, 14

Causes of stillbirth and dystocia, 14

Non-genetic factors, 14

Breed differences and parity effects, 14

Incidences, 14

Genetic parameters, 15

Genetic evaluations, 17

Data structure and models, 17

Concluding remarks and future research , 17

References, 18

Acknowledgements , 21

Publications included in the thesis

- I. Steinbock, L., Näsholm, A., Berglund, B., Johansson, K. and Philipsson, J. 2003. Genetic effects on stillbirth and calving difficulty in Swedish Holsteins at first and second calving. *J. Dairy Sci.* 86; 2228-2235.
- II. Steinbock, L., Johansson, K., Näsholm, A., Berglund, B. and Philipsson, J. 2006. Genetic Effects on Stillbirth and Calving Difficulty in Swedish Red and White Dairy Cattle at First and Second Calving. (Submitted).

Reprints were made with the kind permission of Journal of Dairy Science.

Introduction

Data from the milk recording scheme show that stillbirth rates in first-calving Swedish Holsteins (SLB) have steadily increased since the middle of the 1980s. The rate is presently 10.4%, and the proportion of difficult calvings reported is 6.9% (Swedish Dairy Association, 2005). In subsequent calvings the incidence of stillbirth drops considerably. Interestingly, this contrast – between stillbirth rates in first and later calvings – is not seen in the Swedish Red and White Breed (SRB), which is the other main dairy breed in Sweden. In SRB, calving number makes almost no difference to stillbirth rates (Figure 1). The reasons for this are unknown.

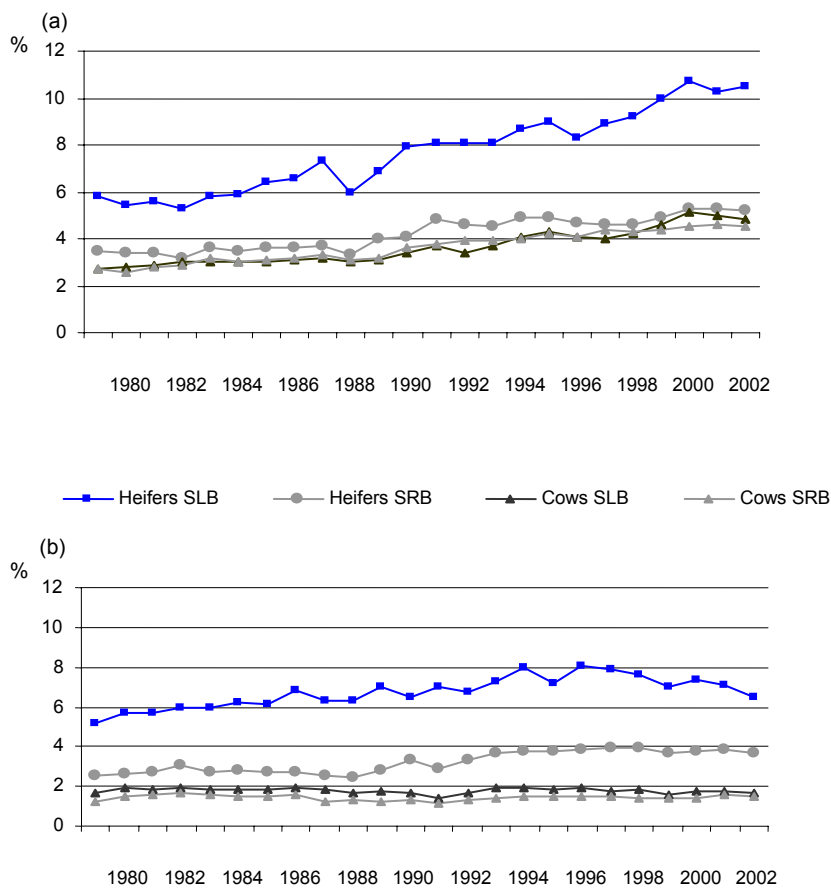


Figure 1. Annual statistics from the milk recording scheme for a) stillbirth (%) and b) calving difficulty (%) for heifers and cows of SRB and SLB.

During the last two decades semen from the high-yielding North American Holstein has been widely imported into Sweden, and the SLB breed is now heavily influenced by Holstein Friesian genes (Philipsson, 2005). In the USA, Holstein Friesians have been shown to have as high an incidence of stillbirths as 13% at first parity (Meyer et al., 2001). In the older type of SLB there was a high proportion of difficult calvings (approx. 16%) but a moderate stillbirth rate (7.5%) at first parity (Elvin, 1965). The stillbirth rate decreased to even lower levels (5-6%) during the 1970s as a result of strategic selection and the use of bulls (Philipsson, 1976a). The causes of stillbirth have changed since then. The problem used to be heavy calves, and therefore difficult calvings; but more recently stillbirth has been connected with vitality (Berglund and Philipsson, 1992). Many calves die with no obvious cause of death (Berglund et al., 2003). About half or more of the stillbirths occur among calves that have not undergone difficult calving (Hagnestam, 2003; Johanson and Berger, 2003).

The overall aims of this study were therefore to illuminate differences in calving traits and their inheritance between the SLB and SRB breeds; and in the process to obtain information permitting improved methods of genetic evaluation to be applied.

Background

Importance of stillbirth and calving difficulty

Stillbirth and calving difficulty are ethically and economically important traits, and it is very much in the interest of both farmers and the public that they occur at the lowest possible levels. From an animal welfare point of view it is unsatisfactory that, roughly speaking, every ninth calf from Holstein first-calvers is dead at birth or dies within 24 hours of being born. In addition to the fact that both the dam and calf may have been suffering during delivery there is a risk that the dam will be seriously injured. Economically, such injury means that stillbirth can introduce costs above those implied by loss of the calf itself. A recent study of Australian Holsteins concluded that the greatest cost associated with calving difficulty was due to reduced fertility, at 33% of total cost for primiparous cows, and 27% for multiparous cows. Loss of the cow was the second largest cost, at 19% and 22%, respectively, for primiparous and multiparous cows. A stillborn calf accounted for 15% of the costs, and extra labour accounted for 18% (McClintock, 2004). The risk of having retained placenta is a fertility problem; it may also influence milk production during the lactation period (Philipsson, 1976c).

Reduced milk production caused by calving difficulty has been found (Djemali et al., 1987; Dematawewa and Berger, 1997). Rajala and Gröhn (1998) found that calving difficulty had no impact on milk yield in first lactation but did affect production in the second and third lactation. The most costly cases of calving difficulty are obviously those that involve surgery or complicated malpresentations, but it is the more ordinary, less expensive cases which, because

they are more frequent, cause the highest average cost across the herd as a whole (McClintock, 2004).

Recording and definition of traits

In Sweden we have access to unique data on calving traits. The Swedish milk recording scheme is integrated with the AI recording scheme and health recording services. As almost 90% of Swedish cows are included in the milk recording scheme, this means that very extensive data are available for research and genetic evaluations (Swedish Dairy Association, 2004).

Stillbirth is often defined as birth in which an animal is born dead or dies during or a short time after parturition. In Swedish genetic evaluation of bulls, and in the analyses of this thesis, the limit for stillbirth is 24 hours after birth. If the dead calf is delivered earlier than 215 days it is categorised as an abortion, and calvings in which gestation ends at 215-240 days are considered early. In our study these categories are excluded from the genetic analyses.

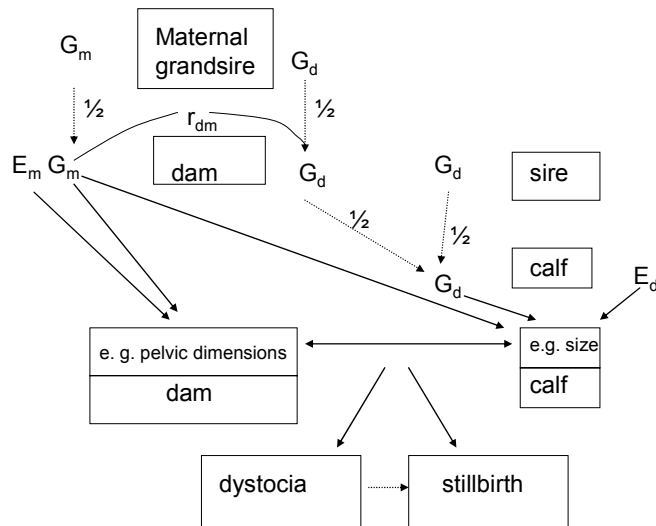
In the Swedish milk recording scheme there are four options to choose from when categorising calving performance. These are: normal calving; difficult calving (where it is stipulated that the heifer or cow was unable to calve without assistance); malpresentation; or no observation on calving performance. In the present work, however, the trait was analysed in two classes: *normal calvings*, which also included records with no observation of calving performance, and *difficult calvings*, which included malpresentations.

Direct and maternal effects

The calving traits, together with such traits as birth weight, are genetically affected not only by the calf itself but also, to a large extent, by characteristics of the dam (Figure 2). The dam's size – especially her rump-width, pelvic opening and angle of pelvic opening – is an important factor, as is the size and fitness of the calf itself (Meijering, 1984). Additive genetic *direct* effect is defined as the ability of the calf to be born. This is measured as variation between sires of the calves. The *maternal* genetic effect is defined as the ability of the dam to give birth, and is largely measured as variation between maternal grandsires of the calves (daughter groups). It is thus important to take the maternal grandsire of the calf into account. Bulls in Sweden are genetically evaluated for calving traits as both sires and maternal grandsires. Both these traits are included in the total merit index.

The size and shape of calf can be unsuitable given the specific size and shape of its dam's pelvic opening; this is often referred to as feto-pelvic incompatibility (Meijering 1984). If bulls known for siring small calves, and therefore easy births, are too widely used they may yield small heifers which themselves might encounter problems when calving the first time. In the majority of studies to be found in literature the genetic correlation between direct and maternal effects was found to be slightly negative for both stillbirth and calving difficulty (Cue and

Hayes, 1985; Dwyer et al., 1986; Manfredi et al., 1991; Luo et al., 2002). An exception is Groen et al. (1998), who found a positive relationship for calving difficulty.



G_d : direct genetic effect, E_d : direct environmental effect
 G_m maternal genetic effect, G_d maternal environmental effect
 R_{dm} genetic correlation between direct and maternal effects

Figure 2. Illustration of the influence of direct and maternal effects on calving (after Meijering, 1984).

Stillbirth has more than one cause (or is multifactorial), and the increase in first-calving SLB is most probably due to a variety of factors (e.g. Berglund, 1996). In a study based on post-mortem examination it was found that only 46% of the stillborn calves had experienced a difficult calving. For about a third of the calves no cause of death could be determined, and these calves were spread among all weight classes except for the one with calf weights above 56 kg (Berglund et al., 2003).

The presence, and variation, in levels of hormones in the blood of both calf and dam may also be a factor in stillbirth and difficult calvings. In an endocrinology study emphasising stillbirth no significant differences were found in placental characteristics of animals giving birth to stillborn, and animals bearing viable, calves (Kornmatitsuk et al., 2002).

Inbreeding may be one factor in calving problems, as has been shown by Adamec et al., (2006). In their study, the unfavourable effect of inbreeding on

calving difficulty and stillbirth was demonstrated. The effect was greatest in first parity cows and declined with parity.

Birth weight and gestation length as related traits

Johanson and Berger, (2003) noticed that short as well as long gestation lengths caused a number of calving problems. The gestation length with minimum risk of mortality was 282 days; the average length in that study was 279 days. The ratio between the cow's and the calf's weight is a good predictor of stillbirth (Johanson and Berger, 2003). A wide variation of birth weight was seen among stillborn calves, but stillborn calves not dead as a result of calving difficulty tended to be lighter than the average for stillborn calves (Berglund et al., 2003). An association between longer gestation length and increased problems with stillbirth and calving difficulty has been seen in many studies (e.g. Philipsson, 1976; McGuirk et al., 1999; Meyer et al., 2001). Inclusion of gestation length in the model, however, gives limited effects on stillbirth and calving difficulty due to the non-linear relationship (Hansen et al., 2004).

Genetic parameters and evaluations

No specific genetic parameters have earlier been estimated for SRB, so the same parameters for calving traits have been used in the Swedish genetic evaluations for both SLB and SRB. Since the prevalence of calving problems clearly differs between the breeds at first calving, it is not obvious that the traits should be treated in genetic evaluations in the same way for both breeds. Similarly, the parameters for SLB have not been updated since long before this study. An update is needed here, as both the population and the characteristics of the traits, especially stillbirths, have changed over recent decades.

In Sweden, since 1994, we have been using a linear BLUP sire-maternal grandsire model for genetic evaluations of stillbirth and difficult calving for bulls, both as sires and maternal grandsires. We have also, as in the other Scandinavian countries, been studying functional traits for the last three decades (Philipsson and Lindhé, 2003). The high stillbirth rate of the Holsteins was a leading concern in the study by Berglund and Philipsson (1992). During the last two years many other countries have started to monitor the calving traits of their Holstein populations. Among the members of Interbull, many countries presently evaluate the bulls for calving difficulty, and the majority of them now also evaluate bulls for stillbirth. International evaluations for calving traits were launched by Interbull in 2005 (Mark et al., 2005).

Stillbirth and calving difficulty are all-or-none traits, which make them complicated to analyse. However, in all studies it is assumed that there is an underlying normal variation of the traits. Ideally, a threshold model would be preferred for such analyses. Such a model is used for the genetic evaluation of calving ease in France (Ducrocq, 2000) and the USA (Van Tassel, 2003). For it to function properly, the structure of the data must not give rise to extreme

categorisation problems of the sort entailing that all observations in one subclass happen to be in the same category. Rather large subclasses are therefore required, and since subclasses of this kind are often not used, linear models for evaluation have in practice been more commonly preferred (e.g. Hagger and Hofer, 1990; Ramirez-Valverde, 2000; Jamrozik et al., 2005).

Objectives of the thesis

The specific aims of this study were:

- to improve our knowledge of genetic variation in stillbirth and calving difficulty, and of the relationship between these two traits, in the two most common Swedish dairy cattle breeds: SLB and SRB.
- to investigate the relationship between first- and second-calvers, and between direct and maternal genetic effects, in respect of stillbirth and calving difficulty in SLB and SRB.
- to ascertain effective ways of analysing such low heritability traits as stillbirth and calving difficulty, that often show a relatively low incidence level, regarding actual populations and herd structures.
- to map out genetic features, and differences between the calving traits, of SLB and SRB that enable separate, well adjusted genetic evaluation programmes for each breed to be set up.
- to provide information that may help to reduce calving problems and stillbirth rates by improving the genetic evaluation of bulls for calving traits.

Summary of the investigations presented

I. Genetic effects on stillbirth and calving difficulty in Swedish Holsteins at first and second calving

Stillbirth and calving difficulty in the SLB population were investigated. All first and second calvings during 1985 and 1996 were analysed. When material from the Swedish Dairy Association had been edited 411,409 first calvings and 281,193 second calvings remained. In this material the incidences were: 7.1% stillbirth and 8.3% difficult calvings in first-calvers; and 2.7% and 4.5% for stillbirths and difficult calvings in second-calvers.

The analyses were performed with linear single trait sire-maternal grandsire models, and with threshold models using a Gibbs sampling technique. The heritabilities obtained for stillbirth at first calving, on the visible scale, were 3% and 4% for direct and maternal effects, respectively. For calving difficulty the

corresponding heritabilities for direct and maternal effects were 5% and 6%, respectively. Inclusion of calving difficulty in the model for stillbirth at first calving resulted in halved heritabilities for both direct and maternal effects. Under the threshold model the heritabilities for stillbirth at first calving were 12% and 8% for direct and maternal effects, respectively. The corresponding figures for calving difficulty were 17% and 12%. At second calving heritabilities were between 2% and 4% for stillbirth and 4-7% for calving difficulty.

At first calving, the genetic correlations between stillbirth and calving difficulty were 0.80 for direct effects and 0.74 for maternal effects. Genetic correlations between bulls estimated breeding values at first and second calving were just under 0.5 for both direct and maternal effects; for calving difficulty they were between 0.6 and 0.7. Differences between bulls, both as sires and as maternal grandsires, were most visible in first-calving results. The heifer's age at calving was an important factor, especially when the heifer was giving birth to a bull calf. Also, for stillbirth the age of heifer was important when the calf was a bull. Results from this study suggest that first-calving records should be used in routine evaluations of bulls for calving performance. Records from both stillbirth and calving difficulty, as well as results for bulls both as sires and maternal grandsires, should be used.

II. Genetic effects on stillbirth and calving difficulty in Swedish Red and White dairy cattle at first and second calving

In SRB, genetic effects on stillbirth and calving difficulty were studied in 804,268 first- and 673,150 second-calvers. Univariate and bivariate linear sire-maternal grandsire models were used to analyse calving data from the period 1985-2000. The difference in mean incidence of stillbirth between first and second parity was small, at 3.6% vs. 2.5%. At first calving the heritability of stillbirth, on the visible scale, was 0.7-1.3% for the direct effect and 0.5-0.9% for the maternal effect. The corresponding figures for calving difficulty were approximately 2.5% and 2%. At second calving heritabilities for the two traits were of the same order as they were at first parity, albeit somewhat lower for stillbirth. The genetic correlations between first- and second-calving results were approximately 0.8 for direct and maternal effects in stillbirth and approximately 0.7 for calving difficulty.

Univariate models for first and second calvings, analysed both separately and together in a repeatability model were compared with a bivariate model which was considered, theoretically, be the most correct. The correlations between bulls' ETAs for stillbirth were 0.94-0.96 between results from first calving analysed with a bivariate model and results from the repeatability model. It was concluded, first, that calving traits at first and second parities could be treated as the same trait, and second, that bivariate analyses, or a repeatability model, including calving results for both heifers and cows should be preferred in genetic evaluations of SRB bulls as sires and maternal grandsires.

General discussion

Causes of stillbirth and calving difficulty

Non-genetic factors

In SLB, the younger the heifer is the more probable it is that difficult calvings will occur. In a small group of very young SRB heifers there were also more problems. The results of this study are in general agreement with those of other studies (e.g. Berger et al., 1992; Fuerst and Egger-Danner, 2003; Hansen, 2004a). The practical lesson of this is that farmers should not let heifers conceive younger than 24 months.

Male calves were more common among stillbirths and difficult calvings. This may be partly explained by the fact that male calves are in general heavier than female calves. Also of equal weight bull calves had more problems (Hagnestam, 2003). The differences between sexes found in the present study were evident in both breeds and are in general agreement with the literature (Meijering, 1984; Meyer et al., 2000). In this study there were also differences at second parity, even if they were not as great. Hansen et al. (2004) found that calves were largest at second calving, but that stillbirth and calving difficulty occurred at least twice as often at first calving.

Season has a large influence. This can probably be explained by the fact that dairy cattle in Sweden are kept indoors from autumn to spring, and in many herds cows are also tethered. Most problems occur in late autumn and winter. During this time the cattle have limited opportunities to exercise. Similar results for calving difficulty and stillbirth were found in earlier Swedish studies (Philipsson, 1976a). Thus the seasonal influence on calving performance has not changed.

Breed differences and parity effects

Incidences

In both breeds, the incidence of stillbirth and calving difficulty were highest at first calving, but the incidence level was much greater in SLB. The stillbirth rate was twice as high in SLB heifers as it was in SRB heifers, and this difference has increased even more in later years (Swedish Dairy Association, 2005). Cows of the two breeds experienced almost the same incidence of stillbirth (see Table 1). The difference in calving traits between first and later parities is confirmed in many other studies (e.g. Bar-Anan et al., 1976; Berger et al., 1992; Meyer et al., 2000; Eriksson et al., 2004). However, the smaller difference in SRB seems rather unique.

Table 1. Incidences (%) of stillbirth (SB) and calving difficulty (CD) for bull and heifer calves

Breed	Parity	SB			CD		
		total	Bulls	Heifers	total	Bulls	Heifers
SRB	1	3.6	4.2	3.0	4.0	5.2	2.8
	2	2.5	2.8	2.3	1.9	2.2	1.4
SLB	1	7.1	9.0	4.7	8.3	10.1	4.3
	2	2.7	3.0	2.8	4.5	3.6	1.1

Calves that are heavier than average tend to cause more calving problems and stillbirths, and very light calves have a higher mortality rate (Berger et al., 1992; Hagnestam, 2003). SLB calves have not become heavier over the last few decades (Hagnestam, 2003), but it is possible that the calves have a different build today – e.g. broader pelvis, larger skull, or deeper chest – and that this lead to problems. In the present study, records of birth weight were not examined, but clearly both a higher mortality rate and more difficult calvings occurred in bull calves of both breeds, especially at first calving.

Genetic parameters

Table 2 summarises the heritabilities estimated in our study. Although heritabilities were low for calving traits, there was, at least at first calving, considerable genetic variation in SLB.

Table 2. A summary of the heritabilities (%) from the papers I and II

	Visible scale				Underlying scale	
	Univariate model		Bivariate model		Calving no.	
	1	2	1	2	1	2
<i>h² stillbirth</i>						
SRB _{dir}	1.1	0.4	1.3	0.8	5.3	3.1
SRB _{mat}	0.5	0.5	0.9	0.8	2.1	3.2
SLB _{dir}	3.8	0.7			14.1	3.9
SLB _{mat}	2.8	0.3			11.3	2.2
<i>h² calving difficulties</i>						
SRB _{dir}	2.6	0.6	2.4	2.2	13.4	5.5
SRB _{mat}	1.8	0.5	2.1	0.8	9.2	2.5
SLB _{dir}	6.2	0.4			18.9	1.8
SLB _{mat}	4.8	0.2			15.1	1.3

Among SLB bulls, there was a variation in the bulls' ETAs for stillbirth rate between 3% and 16%, both as sires and maternal grandsires. At second calving there was much less genetic variation (1-4%), and there the incidences are at what might be considered an acceptable level. In SRB there was less variation overall, and smaller differences between parities. Both for stillbirth and calving difficulty, most studies have found higher levels of genetic variation and heritability at first

parity than they have found at later parities (e.g. Harbers et al., 2000; Fuerst and Egger-Danner, 2003). Ducrocq (2000), however, obtained heritabilities of the same size for stillbirths in both first and later calvings, as well as for direct and maternal effects, at first calving. In beef breeds the differences between heritabilities for calving difficulty at first and later calvings are not as accentuated as they are in general for dairy breeds, but they are nevertheless smaller at second calving (Eriksson, 2004).

In SLB it was shown that heritabilities for stillbirth halve when adjustments are made for calving difficulty. Thus considerable genetic variation in stillbirth rate, or the vitality of calves at birth, remains independent of calving performance.

The heritability estimates for SLB at first calving have increased to almost twice their value in previous investigations in Sweden (Philipsson, 1976b). The stillbirth rate has, however, also increased during the same period and is part of the cause of the higher heritability. These changes in the breed, and the increased genetic variation in stillbirth at first calving, have partly been caused by the influx of North American Holstein Friesian genes that started on a large scale in the 1980s; the influx has continued during the period of the present study. At second calving there has been no increase in heritability and only a moderate increase in the stillbirth rates over the years. This might be due to the fact that the breed has been changed genetically: perhaps the heifers have become in some way less mature at the common calving age, because at second calving there is no obvious trend towards increased problems with stillbirth and calving difficulty.

The heritability of direct effect was usually slightly higher than that of maternal effect. The exceptions were in univariate analyses of stillbirth at second calving, bivariate analyses of stillbirth at first and second calvings, and bivariate analyses of calving difficulty in first and second calvings. These exceptions could be explained by the low incidences and low heritabilities of the traits.

The most common finding in the literature on heritabilities for direct and maternal effects for stillbirth is that the estimates are slightly higher for direct effect than maternal effect (e.g. Fuerst and Egger-Danner, 2003; Hansen et al., 2004b). The reverse of this relationship has, however, also been found. Harbers et al., (2000) obtained a heritability for the direct effect of stillbirth in first parity of 3% (which is slightly lower than ours). Their estimate of the heritability of maternal effect was higher, at 5%.

The estimated heritabilities for stillbirth in SLB, using linear models, were 5% and 6% for direct and maternal effects, respectively. Transformed to the liability scale, they corresponded to 15% and 17%. The heritabilities obtained using a Bayesian threshold model were only slightly lower than the transformed ones. The direct and maternal effects were slightly positively correlated when the threshold model was used, but weak negative correlations were found when the linear model was applied. They were all close to zero, however, which indicates that selection on either effect for stillbirth would not affect the other effect to a significant extent.

For stillbirth and calving difficulty in SLB, the genetic correlation between first and second parity was approximately 0.5 for sires and varied between 0.4 and 0.7 for both traits of maternal grandsires. Even if these correlations not are considered low, results from second calving will, in combination with the low heritabilities and incidences in second parity, fail to increase the accuracy of estimates of the breeding values for bulls in respect of the calving traits. In SRB, however, there were only minor differences, both phenotypically and genetically, between the first two parities for both stillbirth and calving difficulty. The genetic correlations between parities here were also higher, at between 0.7 and 0.8. These results show that, in SLB, stillbirth and calving difficulty at first calving are not the same traits as stillbirth and calving difficulty at second calving; in SRB, on the other hand, these calving traits at different parities can to a much greater extent be regarded as the same traits.

Genetic evaluation

Data structure and models

The analysis of categorical data should theoretically be performed by threshold methods (Gianola, 1982), but these types of method are very time-consuming and require the data to be structured in a certain way. In our study of SLB the Bayesian approach, with Gibbs sampling, functioned quite well. In the SRB population studied, by contrast, there were too few, or no, stillborn calves in many herd-year subclasses, and this created extreme category problems (ECPs). We therefore chose linear models for the analyses of SRB data. We also found that the heritabilities obtained for SLB by the transformation of results on the visible scale to the underlying scale corresponded quite well with results achieved directly from threshold analysis. We conjectured that use of linear models for the genetic evaluation of calving traits may well be satisfactory. This conjecture is well supported by recent literature (Ramirez-Valverde, 2001; Jamrozik et al., 2005).

In SLB, low heritabilities and low incidences in calving traits at later calvings mean that results from calvings after the first should not be used in the genetic evaluation of bulls for calving traits. Neither was there, in our study, any significant genetic variation at second calving. In SRB the situation is different. Here both stillbirth and calving difficulty can be considered as largely the same trait at first and later parities. Consequently, despite the low heritabilities and low incidences, the inclusion of second calving results in the genetic evaluations here would improve the reliabilities of the ETAs of the evaluated bulls by about 50%. The analyses delivered rather similar results for the bivariate and repeatability models.

Concluding remarks and future research

- The two main dairy breeds in Sweden, SLB and SRB, differ remarkably, both phenotypically and genetically, in calving traits at first parity,

whereas no real differences exist at later parities. They therefore require different genetic evaluation programmes.

- In SLB there is nothing to be gained by including results from second and later calvings in the genetic evaluation of bulls for calving traits. In SRB, on the other hand, including results from second calving will significantly improve the accuracy of the bulls' ETAs. Either a bivariate or repeatability model would be sufficient here.
- Small contemporary group sizes, and low incidences and/or heritabilities, make use of a threshold model in the genetic evaluation of calving traits in SRB difficult. The threshold model can, however, be used successfully in analysing calving traits in SLB. Since results from linear analyses correspond satisfactorily with those from analyses using the threshold model, there is at present no reason to replace a simple, well-functioning method with a more time-consuming one.
- In SLB a clear genetic variation in the stillbirth rate, and in the vitality of calves at birth is present independently of calving difficulty.
- In order to minimise calving problems and mortality, heifers of both breeds studied should not conceive younger than 24 months. Late summer or early autumn calvings will reduce problems at calving.
- Research is needed to clarify the reduced vitality of SLB (and more widely, Holstein) calves born at first parity.
- The rising stillbirth rate – reported both in Sweden and internationally for the Holstein breed – calls for international cooperation in research and selection programmes.

References

- Adamec, V., Cassell, B.G., Smith, E.P. & Pearson, R.E. 2006. Effects of inbreeding in the dam on dystocia and stillbirths in US Holsteins. *J. Dairy Sci.* 89, 307-314.
- Bar-Anan, R., Soller, M. & Bowman, J.C. 1976. Genetic and environmental factors affecting the incidence of difficult calving and perinatal calf mortality in Israeli-Friesian dairy herds. *Anim. Prod.* 22, 299-310.
- Berger, P.J., Cubas, A.C., Koehler, K.J. & Healey, M.H. 1992. Factors affecting dystocia and early calf mortality in Angus cows and heifers. *J. Anim. Sci.* 70, 1775-1786.
- Berglund, B. 1996. Ongoing research on the causes of variation in calving performance and stillbirths in Swedish dairy cattle. *Interbull Bulletin* 12, 78-83
- Berglund, B. & Philipsson, J. 1992. Increasing stillbirth rates in the Swedish Friesian population. *Paper in 43rd Annual Meet. of the EAAP, Madrid, Spain 14-17 Sept 1992.*
- Berglund, B., Steinbock, L. & Elvander, M. 2003. Causes of stillbirth and time of death in Swedish Holstein calves examined post mortem. *Acta Vet. Scand.* 44, 111-120.
- Cue, R.I. & Hayes, J.F. 1985. Correlations of various direct and maternal effects for calving ease. *J. Dairy Sci.* 68, 374-381.

- Dematawewa, C.M.B. & Berger, P.J. 1997. Effect of dystocia on yield, fertility and cow losses and an economic evaluation of dystocia scores for Holsteins. *J. Dairy Sci.* 80, 754-761.
- Djemali, M., Freeman, A.E. & Berger, P.J. 1987. Reporting of dystocia scores and effects of dystocia on production, days open, and days dry from dairy herd. *J. Dairy Sci.* 70, 2127-2131.
- Ducrocq, V. 2000. Calving ease evaluation of French dairy bulls with heteroskedastic threshold model with direct and maternal effects. *Interbull Bulletin* 25, 123-130.
- Dwyer, D.J., Schaeffer, L.R. & Kennedy, B.W. 1986. Bias due to corrective matings in sire evaluations for calving ease. *J. Dairy Sci.* 69, 794-799.
- Elvin, S. 1965. Kalvningssvårigheter hos SLB-kvigor; en inventering av orsakerna. *Aktuellt från Lantbrukshögskolan, Husdjur*, 75, 77-81.
- Eriksson, S., Näsholm, A., Johansson, K. & Philipsson, J. 2004. Genetic parameters for calving difficulty, stillbirth and birth weight for Hereford and Charolais at first and later parities. *J. Anim. Sci.* 82, 375-383.
- Fuerst, C. & Egger-Danner, C. 2003. Multivariate genetic evaluation for calving ease and stillbirth in Austria and Germany. *Interbull Bulletin* 31, 47-51.
- Gianola, D. 1982. Theory and analysis of threshold characters. *J. Anim. Sci.* 54, 1079-1099.
- Hagger, C. & Hofer, A. 1990. Genetic Analyses of calving traits in the Swiss Black and White, Baunvieh and Simmental breeds by REML and MAPP procedures. *Livest. Prod. Sci.* 33, 183-198.
- Hagnestam, C. 2003. Orsaker till kalvningssvårigheter och dödfödslar hos förstakalvande lågland [Factors affecting calving difficulty and stillbirth in Swedish Holsteins at first calving]. Swedish University of Agricultural Sciences, Department of Animal Breeding and Genetics, M.Sc. thesis 249. 54 pp.
- Hansen, M., Lund, M.S., Pedersen, J. & Christensen, L.G. 2004a. Genetic parameters for stillbirth in Danish Holstein cows using a Bayesian threshold model. *J. Dairy Sci.* 87, 706-716.
- Hansen, M., Lund, M.S., Pedersen, J. & Christensen, L.G. 2004b. Gestation length in Danish Holsteins has weak genetic associations with stillbirth, calving difficulty and calf size. *Livest. Prod. Sci.* 91, 23-33.
- Harbers, A., Segeren, L. & de Jong, G. 2000. Genetic parameters for stillbirth in the Netherlands. *Interbull Bulletin* 25, 117-122.
- Jamrozik, J., Fatehi, J., Kistemaker, G.J. & Schaeffer, L.R. 2005. Estimates of genetic parameters for Canadian Holstein female reproduction traits. *J. Dairy Sci.* 88, 2199-2208.
- Johanson, J.M. & Berger, P.J. 2003. Birth weight as a predictor of calving ease and perinatal mortality in Holstein cattle. *J. Dairy Sci.* 86, 3745-3755.
- Kornmatitsuk, B., Franzén, G., Gustafsson, H. & Kindahl, H. 2002. Endocrine measurements and calving performance of Swedish Red and White and Swedish Holstein dairy cattle. *Acta Vet. Scand.* 44, 21-33.
- Luo, M.F., Boettcher, P.J., Schaeffer, L.R. & Dekkers, J.C.M. 2002. Estimation of genetic parameters of calving ease in first and second parities of Canadian Holsteins using Bayesian methods. *Livest. Prod. Sci.* 74, 175-184.
- Manfredi, E., Ducrocq, V. & Foulley, J.L. 1991. Genetic analysis of dystocia in dairy cattle. *J. Dairy Sci.* 74, 1715-1723.
- Mark, T., Jakobsen, J., Jorjani, H., Fikse, W.F. & Philipsson, J. 2005. International trends in recording and genetic evaluation of functional traits in dairy cattle. *56th Annual Meet. of the EAAP. 2005. Uppsala, Sweden Paper abstract no. 536 session CG2.1.*
- McClintock, S. 2004. A Genetic evaluation of dystocia in Australian Holstein Friesian cattle. PhD.thesis. Institute of Land and Food Resources, University of Melbourne. 245 pp.
- McGuirk, B.J., Going, I. & Gilmour, A.R. 1999. The genetic evaluation of UK Holstein Friesian sires for calving ease and related traits. *Anim. Sci.* 68, 413-422.
- Meijering, A. 1984. Dystocia and stillbirths in cattle - a review of causes, relations and implications. *Livest. Prod. Sci.* 11, 143-174.
- Meyer, C.L., Berger, P.J. & Koehler, K.J. 2000. Interactions among factors affecting stillbirths in Holstein cattle in the United States. *J. Dairy Sci.* 83, 2657-2663.

- Meyer, C.L., Berger, P.J., Koehler, K.J., Thompson, J.R. & Sattler, C.G. 2001. Phenotypic trends in incidence of stillbirth for Holsteins in the United States. *J. Dairy Sci.* 84, 515-523.
- Philipsson, J. 1976a. Studies on calving difficulty, stillbirth and associated factors in Swedish cattle breeds. I. General introduction and breed averages. *Acta Agric. Scand.* 26, 151-164.
- Philipsson, J. 1976b. Studies on calving difficulty, stillbirth and associated factors in Swedish cattle breeds. V. Effects of calving performance and stillbirth in Swedish Friesian heifers on productivity in the subsequent lactation. *Acta Agric. Scand.* 26, 230-234.
- Philipsson, J. 1976c. Studies on calving difficulty, stillbirth and associated factors in Swedish cattle breeds. III. Genetic parameters. *Acta Agric. Scand.* 26, 211-220.
- Philipsson, J. 2005. INTERBULL – How it began and some achievements. *Interbull Bulletin* 33, 131-135.
- Philipsson, J. & Lindhé, B. 2003. Experiences of including reproduction and health traits in Scandinavian dairy cattle breeding programmes. *Livest. Prod. Sci.* 83, 99-112.
- Rajala, P.J. & Gröhn, Y.T. 1998. Effects of dystocia, retained placenta and metritis on milk yield in dairy cows. *J. Dairy Sci.* 81, 3172-3181.
- Ramirez-Valverde, R., Misztal, I. & Bertrand, J.K. 2001. Comparison of threshold vs. linear and animal vs. sire models for predicting direct and maternal genetic effects on calving difficulty. *J. Anim. Sci.* 79, 333-338.
- Swedish Dairy Association. 2005. Cattle Statistics 2004. [Husdjursstatistik 2004]. Svensk Mjök, SE-631 84 Eskilstuna Sweden.
- VanRaden, P.M. 2002. Selection of dairy cattle for lifetime profit. *Proc. 7th World Cong. Genetics Appl. Livest. Prod., Montpellier, France, 01-21.*
- Van Tassel, C.P., Wiggans, G.R. & Misztal, I. 2003. Implementation of a sire-maternal grandsire model for evaluation of calving ease in the United States. *J. Dairy Sci.* 86, 3366-3373.
- Weller, J.I, Misztal, I. & Gianola, D. 1988. Genetic analysis of dystocia and calf mortality in Israeli-Holsteins by threshold and linear models. *J. Dairy Sci.* 71, 2491-2501.

Acknowledgements

This work was performed at the Department of Animal Breeding and Genetics at the Swedish University of Agricultural Science. The work was financially supported from Swedish Farmers' Foundation for Agricultural Research, (SLF), Agria Insurance Ltd and the interdisciplinary research programs "Animal production – health, management and ethics" and "Animal welfare for quality in food production" at SLU, which is gratefully acknowledged. I am also grateful to the Swedish Dairy Association for generously providing the data from the milk recording scheme.

There are so many people who have supported and encouraged me during all the time I have been working with this thesis. I wish to express my sincere gratitude to everyone at the department for providing a stimulating atmosphere to work in.

Jag vill speciellt tacka:

Jan Philipsson, min huvudhandledare, tillika avdelningschef och prefekt, för det engagemang och brinnande intresse för ämnet Du hela tiden har utstrålat. Tack också för att Du stöttat, hjälpt till och trott på att det skulle bli en avhandling till slut.

Britt Berglund, biträdande handledare, för att Du sett till att detta projekt blivit till genom att ha utfört ett digert förarbete som ligger till grund för detta arbete. Tack också för Din noggrannhet och känsla för detaljer som gjort mina manus bättre.

Anna Näsholm, biträdande handledare, för all hjälp med DMU-körningar och tolkningar av resultaten av dessa. Tack för alla diskussioner om maternella effekter och annat.

Kjell Johansson, biträdande handledare, för att ha ledsagat mig in i en liten, liten del av den Bayesiska världen, och hjälpt mig tolka resultaten av mina tröskelanalyser. Tack också för alla diskussioner om skidåkning och träning i allmänhet, hoppas det blir någon skidresa igen!

Erling Strandberg, för att det var hos Dig som min tid på institutionen började i och med mitt examensarbete och för att Du alltid kunnat förklara krångliga saker på ett lättfattligt sätt.

Siw Karlsson, för allt möjligt som jag behövt hjälp med under alla år på nötavdelningen. Ett extra varmt tack för allt arbete Du lagt ner under slutet med att få min avhandling färdig för tryck, det var värt jättemycket!

Britt-Marie Gillberg och Monica Jansson, för att Ni gärna hjälpt till med allt, stort som smått som jag har behövt, och svarat på alla frågor jag ställt.

Dan Englund och Rolf Lund, för all hjälp med datorer och nätverk och problem med detta som uppstått under åren.

Alla doktorandkollegor, forna så väl som nuvarande, som gjort att det alltid varit trevligt att ingå i doktorandgruppen och för att tillsammans med alla andra skapat en så trevlig stämning på institutionen.

Ett särskilt tack går till Katja Grandinson som tecknat den fina kalven på avhandlingens framsida. Tack också för att Du alltid varit ett stöd och peppat mig, särskilt på slutet, och för allt prat om hundar, löpning och allt möjligt annat. Det har varit jättekul att ha Dig som löparkompis, hoppas att vi får till fler motionslopp tillsammans. Jag är också otroligt glad för att jag fått vara inhyst i Ditt rum den sista tiden och bara kunnat komma dit och arbeta när jag velat, jättegulligt av Dig!

Till min familj, som alltid finns för mig vill jag rikta ett speciellt tack, älskar Er!