Genetic Possibilities to Reduce Calf Mortality

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Abstract
Calf mortality is a trait that needs more attention especially because the stillbirth rates have increased within the Holstein population. In Denmark the stillbirth rate is 11% at first calving and 6% at later calvings. With this background a PhD study, which aimed to describe the genetic possibilities to reduce the calf mortality, has been carried out. The study showed that stillbirth at first calving has high genetic variance both as a direct (calf) trait and as a maternal (cow) trait.
At later calvings the genetic variance is much lower. The calf mortality after birth was found to have low genetic variance but management practices were found to be quite important for this trait. Stillbirth needs to be recorded, monitored, and genetically evaluated to reduce the stillbirth rate.
A genetic evaluation for calving ease only, is not efficient to reduce the stillbirth rate, because the correlation between calving ease and stillbirth is only moderately high. The Danish calving and birth index consist of information of stillbirth, calving difficulty, and calf size. The indices are found to be efficient tools for lowering the stillbirth rate. The most important and efficient way to gain long-term genetic improvements of the stillbirth rate is to take direct and maternal effects of calving traits into account when selecting sires of sons. Sires of Danish AI-bulls have historically been chosen without putting much emphasis on calving traits. However, it is my impression that Danish Holstein breeders are now motivated to reduce the mortality.

Background
Calf mortality is a trait which has an ethical importance but indeed also an economic importance on the dairy farm. The economic importance of calf mortality consists of the loss of the calf and the additional work relating to mortality. Calf mortality at birth is also associated with more calving difficulties and health problems for the cows. Therefore, good arguments for lowering the calf mortality rate exist. Action can be taken by improving management factors and by improving the genetic factors deciding the ability of the calf to survive. The aim of the article is to describe the genetic possibilities that may reduce the calf mortality rate. My focus is on calf mortality at birth (also known as stillbirth) but also calf mortality after birth has my attention. This article is based on results from the PhD thesis (Hansen, 2004) combined with updated information from the Danish Cattle Federation.

Danish recording system
Farmers in Denmark have recorded stillbirth, calving difficulty, and calf size since 1985. Approximately 85% of all the calvings in Denmark have records of calving difficulty and calf size. For stillbirth it is even higher and since 1998 new legislation has forced farmers to record stillbirth at all calvings. This legislation also forced farmers to record all deaths, slaughterings and ovements of living cattle. These data have made it possible to record and analyse the mortality of calves after birth. Based on all these records the Danish Cattle Federation is monitoring the mortality of calves and publishing the result on the web (Table 1).

Table 1. *Calf mortality at first and later calvings, and calf mortality from 1 to 180 days of age for Danish dairy breeds in 2004 (Danish Cattle Federation, 2005a).*

	Danish Red	Danish Holstein	Danish Jersey	Danish Red Holstein
Mortality at first calving, %	7.4	11.1	6.9	12.8
Mortality at later calving, %	4.4	6.1	4.0	7.1
Mortality from 1 to 180 days of age, %	6.2	6.1	12.5	5.4

In the Danish Holstein population the stillbirth rate has increased. (Figure 1). The stillbirth rate at first calving was 8% in 1985 while today it is 11%. Similar trends have been observed in Sweden (Steinbock et al., 2003), in The Netherlands (Harbers et al., 2000), in the US (Meyer et al., 2001) and probably also in other countries. Hansen et al. (2004) found that at least 50% of the increase in the stillbirth rate was caused by genetic factors while the remaining was due to changes in management.

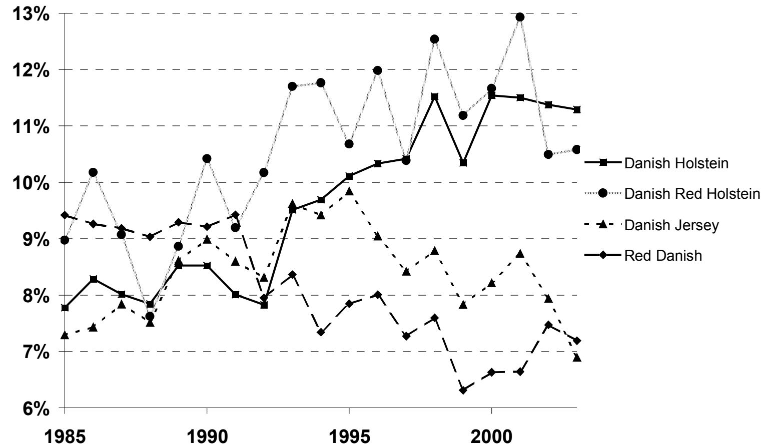


Figure 1. *Stillbirth rates at first calving for all single born calves.*

Danish calving index and birth index

In order to reduce stillbirths and calving difficulties by genetic means we use a birth index and a calving index (Danish Cattle Federation, 2005b). The birth index is a breeding value describing the ability of sires to breed easily born and live born calves (direct traits). The birth index is important for identifying "low-risk" sires for heifer mating. The calving index is a breeding value describing the ability of daughters of sires to give birth to live born calves and to have easy calvings (maternal traits). The direct and maternal traits are calculated simultaneously in a sire - maternal grandsire multi-trait model which combines the following six traits:

- tillbirth, first calving
- Calving ease, first calving
- Size of calf, first calving
- Stillbirth, later calvings
- Calving ease, later calvings
- Size of calf, later calvings.

The genetic evaluation uses all the correlations between these traits. The most important traits in the birth and calving index are stillbirth and calving difficulty at first calving as they receive around 80% of the weight. Calf size is only included as an indicator trait and is not given any weight. The indicies use a rolling base consisting of 7-8 years old AI-sires and are from April 2005 adjusted to a standard deviation of 10 for sires in the base. Previously the standard deviation was 5. The calving index has been included in the Danish S-index (total merit index) since 1982 and recently in January 2005 we also included the birth index in the S-index. The weight is 6% for the calving index and 6% for the birth index.

Genetic variation

Mortality at birth

Large genetic variation exists for stillbirth and calving difficulty. The genetic variation consists of two parts: Direct effects (genetic variation in the calf) and maternal effects (genetic variation in the dam). The direct effects of stillbirth describe the calf's ability to survive birth. This trait is closely related to the size of the calf. The maternal effects of stillbirth describe the cow's ability to give birth to a living calf. Because calving traits are affected by direct and maternal effects, both these effects must be taken into account simultaneously (when analysing calving data).

The genetic variation of stillbirth can be expressed by Predicted Transmitting Abilities (PTA). The PTA shows the effect of sires when used randomly in the population. The distribution of PTA for sires used in Denmark with more than 1.000 progeny is shown in Figure 2. We see that large genetic differences exist between the best and the poorest sires for both direct and maternal effects at the PTA range from 5% to 18%. Note that for the direct effects not many sires with poor PTA are included because these sires are generally not used on heifers.

To illustrate the variety in genetic differences between sires, the effect in percent units of the official Danish birth index and calving index are given in Table 2. If the mean is 11% and sire A has a birth index of 100 and sire B has a birth index of 90, the observed stillbirth rate in their calves would be 11% for sire A and 13.2% for sire B.

Mortality after birth

The genetic variation of mortality after birth is not as large as the genetic variation of birth. At present no official evaluation of the mortality after birth exists, but Hansen et al.(2004) made genetic studies of this trait. If an index was made with a standard deviation of 10 for sires in the base, the effect of 10 index units would give a difference of 0.6 percent units in the progeny. Therefore, the genetic influence of this trait is moderate. However, the study revealed large differences between herds, indicating that management practices on the farm are very important for keeping the calves alive.

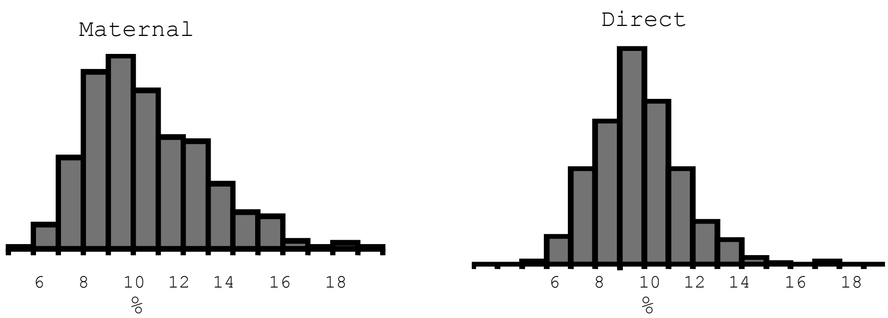


Figure 2. *Distribution of maternal and direct PTA for percent stillbirth at first calving for sires with more than 1.000 calves.*

Table 2. *Effect in progeny of a difference in 10 index units for the sire. The standard deviation of the index is 10.*

		Effect of 10 index units
Birth index[1]	Mortality at first calving, % units	2.3
	Calving difficulty at first calving, % units	3.2
Calving index[2]	Mortality at first calving, % units	1.9
	Calving difficulty at first calving, % units	1.9
Mortality after birth index[2]	Mortality 1-180 days of age, % units	0.6

1) Official index
2) No official index exists.

Correlations between calving traits

From a dataset consisting of 185.000 cows, Hansen (2004) estimated the genetic parameters between all the Danish calving traits: Stillbirth, calving difficulties and calf size. This knowledge is important for understanding the calving traits and for constructing efficient selection tools.

The study confirmed that the direct effects (calf effects) of stillbirth, calving difficulty and calf size are closely associated, as the correlations ranged from 0.69 to 0.93 (Table 3). It means that the size of the calf to a large degree determines the direct stillbirth effects, but other genes also determine the vitality of the calf.

For maternal effects the associations between traits are smaller (Table 4). This means that it is not efficient to select for the maternal effect of calving difficulty only in order to reduce the maternal effects of stillbirth. It is necessary to have an evaluation for both calving difficulty and stillbirth.

Table 3. *Estimates of heritability and genetic correlations for direct effects at first calving.*

		Correlation	
	Heritability	Calving difficulty	Calf size
Stillbirth	.05	.83	.69
Calving difficulty	.10		.93
Calf size	.19		

Table 4. *Estimates of heritability and genetic correlations for maternal effects at first calving.*

		Correlation	
	Heritability	Calving difficulty	Calf size
Stillbirth	.06	.62	.01
Calving difficulty	.06		.45
Calf size	.04		

For both the direct and maternal effects the heritability was found to be much lower at the second calving than at the first calving (Table 5). For the direct effects there seem to be very high genetic correlations between the traits at the first and second (0.89 to 0.99) (Table 6), but because the heritability is lower at the second calving the magnitude of the genetic effects are much smaller
at the second calving.

The genetic correlations between the same maternal traits at first and second calving ranged from 0.74 to 0.88 (Table 7). This means that it is not the exact same genes that affect the ability of the cow to calve a live-born calf at the first calving and at later calvings. In many countries first and later calving traits are treated as the same traits. This is a simplification because the heritability is much lower at later lactations and because the genetic associations between first and second maternal calving traits are only moderately high.

Table 5. *Heritabilities for direct and maternal effects at second calving.*

	h^2 direct effects	h^2 maternal effects
Stillbirth	0.011	0.004
Calving difficulty	0.049	0.027
Calf size	0.141	0.035

Table 6. *Estimated genetic correlations between calving traits at first and second calving. Direct effects.*

		Second calving Stillbirth	Calving difficulty	Calf size
First	Stillbirth	.89	.70	.62
Calving	Calving difficulty	.81	.99	.91
	Calf size	.72	.94	.99

Table 7. *Estimated genetic correlations between calving traits at first and second calving. Maternal effects.*

		Second calving Stillbirth	Calving difficulty	Calf size
First	Stillbirth	.81	.34	-.11
Calving	Calving difficulty	.77	.74	.24
	Calf size	.29	.53	.88

Discussion

Reliability of birth index

In most countries farmers want to select "low-risk" sires for heifer mating. In some countries the young sires are seldom used on heifers. The sire's birth index will then be based on information from later calvings where the heritability is very low. Thereby, the birth index will have a low reliability and there is a risk that the farmer will observe calving difficulties when his heifers are calving.

In Denmark 10 to15% of the heifers are mated with young sires. Thereby, the birth index is only partly based on information from first calving. When a limited number of progeny are born from first calving heifers the calf size is a very important source of information in the birth index.
The information from calf size will improve the reliability of the birth index because the heritability of calf size at first and later calvings is high and because the genetic correlations to stillbirth and calving difficulties at first calving are high. Therefore, a typical Danish proven bull with 35 calves from first calving and 215 calves from later calvings has a reliability of the birth index on 75%, which is fairly high for a functional trait.

The Danish testing scheme is working

To illustrate that the Danish testing scheme works, the development of the stillbirth rate of calves from second batch of a Danish sire (proven) is compared to calves from first batch of a Danish sire (unproven) and to calves with a foreign proven sire (Figure 3).

The stillbirth rate was in general the lowest for calves with a Danish proven sire. Calves with a foreign proven sire, had in general high stillbirth rates (10% to 12%) at the first calving in the period from 1985 to 2003. Within the same period the stillbirth rate for calves with a Danish proven sire increased from 8% to 10%. However, the stillbirth rate for calves with Danish unproven sires increased from 8% to 13%. This illustrates that the Danish progeny testing for finding "low-risk" sires has worked.

The stillbirth rate in calves with unproven Danish bulls as maternal grandsires increased dramatically from 7.5% to 13.5%. A similar increase was observed for calves with foreign maternal grandsires. However, the increase in the stillbirth rate was less dramatic for calves with proven Danish bulls as maternal grandsires (8% to 10%). This illustrates that cows with a Danish proven sire had a better calving performance than cows with Danish unproven sires and cows with a foreign proven sire.

Even though Figure 3 is produced on raw means of field data, it seems evident that the genetic evaluation and selection of Danish proven bulls for the calving traits has reduced the increase in the stillbirth rate.

In accordance with results from the genetic evaluation these result indicate that the foreign bulls used in Denmark have on average been genetically poorer for viability at birth than the Danish proven bulls. As foreign sires have been favoured as sires of Danish AI-bulls, the genetic level for viability birth for the Danish sires has decreased. Historically, we haven't put much emphasis on direct and maternal calving traits when selecting sires of sons. It is the my clear impression that this has changed now because both Danish farmers and consumers have become more concerned about the stillbirth rates and are motivated to reduce the problem.

Conclusion

It was found that the genetic variance of stillbirth at first calving is considerable. This means that selection for this trait can lower the current stillbirth rates. The calf mortality after birth is to a lesser degree determined by genetic effects, but management practices are very important for this trait.
As a conclusion I have the following recommendations for reducing the calf mortality rates.

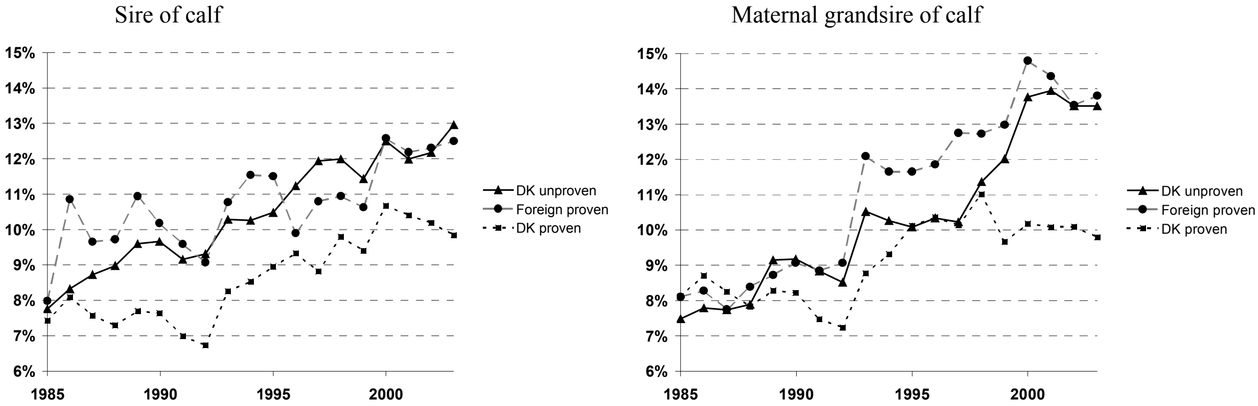
Data recording:
- Record stillbirth, calving difficulty, and calf size at all calvings
- Record of all births, deaths, and movements of all calves
- Monitor and publish the current levels
- Inform and teach about good management practices.

Genetic evaluation of calving traits:
- Need to handle direct and maternal effects simultaneously
- Need to consist of stillbirth and calving difficulty, as they are different traits
- Information of calf size or birth weight can increase the accuracy on the birth index
- First and later calvings should be treated as different traits.

Selection for calving traits:
-For any genetic improvement of the calving traits both the direct and maternal effects need to be included in the breeding goal (total merit index)
- The most important issue for long-term genetic improvements of the stillbirth rate:

Direct and maternal effects of stillbirth have to be taken into account when selecting sires of sons!

Figure 3. Percent stillbirth of Danish Holstein calves at first calving dependent on the sire of the calf and



the maternal grandsire of the calf.

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