Possibilities and needs for selection against metabolic diseases in dairy cattle

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Abstract

The genetic background and the genetic variation for metabolic disorders in dairy cattle are discussed. The genetic relationship between milk yield and ketosis and milk fever is discussed. It is also illustrated by data from the Norwegian dairy cattle breeding program. Further it is discussed how and if these traits should be used as selection criteria or not.

1. Introduction

High yielding dairy cows are in a situation where metabolic problems like ketosis and milk fever may occur. The possibility for these problems seem to be increasing with increasing yield. An important question is therefore: Does selection for higher milk yield increase the risk for these metabolic disorders ?

There are investigations showing that such a risk is real. Then the next question is if these traits should be included in the selectin or not. In this paper the genetic background for these traits, the genetic relationship with mik yield and how it is possible to include these traits are discussed. Mastitis is also included as a tool for comparison.

2. Genetic variation

Most studies show that disease traits have low heritabilities, below 0.10 and usually within the range 0.03 - 0.05, Solbu (1984) and Simianer et al. (1991). From these results it is likely to draw the conclusion that it is impossible to select against disease traits. It also seems possible to state that any other selectin should have very little influence since the heritabilities are so small.

The heritabilities, however, do not tell the complete story. There is a large genetic variation in these traits. Consequently some bulls give daughters that are very poor, and some give daughters that are very good with respect to these traits.

Milk fever is in a special situation because there are very low frequencies in first and second lactations (Table 1). Because of that there has been carried out very few analyses of heritability based on direct informations about this disease, Dyrendahl et al. (1972) and Lin et al. (1989).

In these studies they found heritabilities above 0.2 - 0.4 when using lactations later than the second. Data from the third lactation should be useful, but at this stage effects of culling may influence the results. This also makes problems when estimating genetic correlations between milk fever and other traits. Based on how the background of the diseases it is likely to believe that milk fever is more affected by genetic factors than both mastitis and ketosis. Milk fever is a very well defined situation, and less factors seem to be involved than for ketosis. On the other hand this alone is no guarantee for influence by genetic factors.

In the Norwegian dairy cattle breeding program, diseases have been recorded from the early 70's, and the disease traits mastitis and ketosis have been includede in the selection from 1978.

The reason for including ketosis is that the frquency of this disorder is very high in Norway. This is a result of feeding practises and few available feedstuffs. Because of the climate mostly grass silage of varying quality and concentrates are fed.

Milk fever has never been included as a selection criterion. It is however recorded, and the bulls are progeny tested using the records from the daughters in the third lactation. When finding the predicted breeding values the same heritability as for mastitis is used, 0.03. To use informations from the first and second lactations are not possible because of low frequencies. This is shown in Table 1. The figures are estimated by the model we use for breeding values for mastitis and ketosis. It is a BLUP sire model run within batch of bulls, one batch of bulls is the group entering the progeny testing each year. One batch counts 125 - 130 bulls.

The results clearly demonstrate that these diseases behave quite different. While mastitis and also ketosis occur at a relative high frequency in the first lactation, milk fever is of no importance until the third lactation.

The diseases also are quite different with regard to correlation between estimated breeding values for different lactations. For mastitis and ketosis these correlations are from 0.4 to 0.6 in the dataset in table 1, while for milk fever the correlations are zero between results for the first lactation and later lactations. The correlation between the milk fever results in second and third lactation is around 0.2.

These differences give us important informations: With the low frequencies milk fever is of much less economic importance than the two other traits in the first two lactations, and it is almost impossible to progeny test bulls based on the first two lactations. On the other hand when milk fever occures it gives more complicated disease situations, especially compared to ketosis.

3. Relationship with milk yield

The genetic correlations between milk yield and most of the disease traits are found to be undesirable, Simianer et al. (1991).

As a result of this biological fact, selection for milk yield alone will in the long term give cows that are more susceptible to diseases like mastitis, ketosis and maybe also milk fever.

The genetic correlations are in most studies found to be 0.2 - 0.4. Simianer et al. (1991) found some larger correlations, 0.5 - 0.6 between milk yield and mastitis and ketosis. It is possible to avoid future problems even with these correlations, but to obtain that it is required to include these traits in some way in the selection program.

The question is if it is possible to estimate any relationship between milk fever and milk yield. To illustrate the situation, it is looked at the disease frequencies for groups of bulls, (Table 2). The grouping of bulls is done according to their breeding values for milk yield. Protein yield is used as the trait milk yield. This gives the same effect as strong selection for or against protein yield. The top ten bulls for breeding values for protein yield is in the high group for each year, and the ten bulls with the lowest breeding values for protein yield in th low group. The difference between the groups in genotype for protein yield is about 40 kg.

The results in Table 2 demonstrate the relationship between milk yield and mastitis and ketosis. If milk volume had been used as expression of milk yield, the effect would have been even more clear. Most reports of genetic correlations between milk traits and diseases show desirable correlations with content of the milk as fat and protein. Protein yield is a combination of volume and protein percentage, and therefore the correlation is not as strong as with milk volume alone. An other point is that these bulls are all a result from previous selection for both yield and disease resistance.

It is carried out a number of studies to use analyses of blood samples or milk samples to study ketosis and milk fever,i.e. Tveit et al. (1991) and Tveit et al. (1992). To study ketosis or the likelihood for a cow to come into that stage, the plasma acetoacetate concentration was analysed. The heritability of this trait was found to be 0.11 with a genetic correlation of 0.87 with milk yield.

With regard to milk fever the plasma calcium level was analysed. This trait was found to have a heritability of 0.11 (Tveit et al. 1991), and a genetic correlation with milk yield of -0.35.

4. Discussion and conclusions

It is a well documented fact that there is an unfavourable correlation between milk yield and the likelihood for a cow to get ketosis. There is both an environmental and a gentic relationship. Still it is not obvious if ketosis or any indirect measurement of ketosis should be included in a selection program. It may be of interest if it is a high frequency of cows with the clear ketosis symptomes. But in a situation with no limits of feed stuffs of good quality this seems to be a minor problem. The feeding regime is also of great importance.

It is not so clear if there is a similar genetic correlation between milk fever and milk yield, but the findings reported above from studying the plasma calcium level indicate an unfavourable correlation between milk yield and milk fever. It is however difficult to draw any firm conclusions. There may also be an effect of selection for milk yield that the cows are more able to withstand a low plasma calcium level before showing milk fever symptomes.

The same theory may apply to ketosis.

The conclusion seems to be that ketosis and milk fever do not need to be independent selection criteria. But in a complete dairy cattle breeding program, diseases should be recorded. Health should be selected for as two traits:

1. Mastitis resistance.
2. Resistance to all other diseases including metabolic disorders.

A very important extra gain from this recording is the ability to know exactly what is going on in the population. In that way it is always possible to take the correct action when necessary. This recording also gives a good tool for veterinary research.

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Table 1. Average frequencies, in percentages, of mastitis, ketosis and milk fever for Norwegian bulls with the first progeny tests in 1992 and 1993. Results for the bulls' daughter groups with the maximum and minimum frequencies are also shown. Estimated with a BLUP sire model.

Mastitis:	1. lact.	24.8	14.8	34.7	24.1	17.7	35.4
	2. lact.	27.3	19.6	36.3	27.6	20.9	38.1
	3. lact.	32.1	26.3	42.4	32.3	24.0	42.4
Ketosis:	1. lact.	10.4	5.2	16.6	8.5	4.0	15.8
	2. lact.	10.4	5.4	17.1	10.7	4.5	20.4
	3. lact.	12.3	5.4	19.0	12.2	6.2	19.1
Milk fever:	1. lact.	0.3	0.0	1.2	0.3	0.0	1.1
	2. lact.	2.2	0.0	6.6	2.0	0.1	4.8
	3. lact.	10.1	6.5	16.2	9.2	4.2	17.7

Number of daughters per bull is on average: 1. lact. 294
2. lact 175
3. lact 110

Table 2. Average frequencies, in percentages, of mastitis, ketosis and milk fever for bulls with extreme breeding values for protein yield. Results for the daughters groups with the maximum and minimum frequencies are also shown.

Trait		Bulls with the first progeny test in: 1992 average	min.	max.	1993 average	min.	max.
High protein yield, 10 bulls each year							
Mastitis:	1. lact.	26.6	18.0	34.7	25.2	20.0	31.1
	2. lact.	27.6	23.9	31.6	28.2	23.8	32.3
	3. lact.	32.9	26.8	37.1	33.1	26.4	37.7
Ketosis:	1. lact.	11.0	7.6	16.5	9.0	7.7	11.1
	2. lact.	10.1	6.7	13.3	11.8	8.8	16.5
	3. lact.	12.7	8.7	17.4	11.7	8.1	15.0
Milk fever:	1. lact.	0.3	0.1	0.5	0.3	0.0	0.8
	2. lact.	2.1	0.3	5.0	2.1	0.6	3.6
	3. lact.	10.5	8.0	14.5	8.6	7.6	10.9
Low protein yield, 10 bulls each year							
Mastitis:	1. lact.	24.5	19.3	33.4	21.7	18.1	27.4
	2. lact.	27.0	23.1	31.3	26.6	21.7	34.6
	3. lact.	32.2	27.9	35.6	30.2	26.1	35.3
Ketosis:	1. lact.	8.7	5.7	13.0	6.7	4.8	10.6
	2. lact.	10.2	7.2	13.7	9.6	4.5	14.6
	3. lact.	11.6	8.5	15.2	11.4	6.4	17.2
Milk fever:	1. lact.	0.2	0.0	0.6	0.2	0.0	0.5
	2. lact.	2.4	0.8	3.7	1.6	0.2	2.6
	3. lact.	10.0	7.7	11.6	8.5	6.4	16.7