Statistical Indicators
E-44
Breeding value metabolic disorders

▪ Introduction

Animal health remains an important topic within herd management in the dairy industry. More and more farmers record health issues in their management systems. Some of these health issues are metabolic disorders. Metabolic disorders cause high treatment costs and a reduction in milk yield. The farmer recorded data that is becoming available via management systems gives the opportunity to develop breeding values to select against metabolic disorders.

▪ Traits and breeding goal

In the breeding value estimation of metabolic disorders, two disorders are analysed: milk fever (MFE) and clinical ketosis (CKE).

Metabolic disorders are different for heifers than for cows, therefore in the breeding value estimation a distinction is made between parity 1 (heifers), parity 2 (young cows) and parity 3+ (older cows). Because MFE almost never occurs in the first two lactations, only the breeding value for parity 3+ is published. For CKE the breeding values of parity 1, 2 and 3+ are combined into an overall breeding

▪ Data

Observations
Data about metabolic disorders becomes available as farmer recorded observations in an animal health system. The traits are analysed based on a 0/100 score. Only the treated animals for the specific disorder are in the dataset, they are categorized as sick (score 100). All herd mates at that specific moment were categorised as healthy for that disorder (score 0).

Selection data for the breeding value estimation
Data is used in the breeding value estimation when they meet the following requirements:
1. A cow must be herd book registered (S) and the sire of the cow must be known;
2. Treatment and diagnoses before January 1st, 2006 are not included;
3. If treatment and diagnosis are executed or observed before the first known calving date, the data is not included;
4. If various diagnoses are recorded per metabolic disorder per cow-herd-year combination, then only one diagnoses per metabolic disorder is included;
5. A minimum of 3% of the animals present on the farm in one year have a diagnosis;
6. Diagnoses within 20 days of a previous diagnosis are excluded;
7. Age at calving is a minimum of 610 days;

▪ Statistical model

The breeding values for metabolic disorders are estimated with an animal model, following the BLUP technique (Best Linear Unbiased Prediction). All traits are analysed with the same model, with little differences for parity 1, 2 and 3+. For parity 3+ more than one observation is possible, due to more lactations, therefore a permanent environmental effect is included.

Different statistical models are used for the various parities:

$Y1_{ijkmno} = BJ_i + YM_j + AGE\_C_k + HET_m + REC_n + INT_o + A_p + Error_{ijkmnop}$
$Y2_{ijlmnop} = HYi + YM_j + HET_m + REC_n + INT_o + A_p + PERM_q + Error_{ijlmnopq}$
$Y3_{ijlmnop} = HYi + YM_j + PAR_l + HET_m + REC_n + INT_o + A_p + PERM_q + Error_{ijlmnopq}$

in which:
$Y1_{ijkmno}$: Observation for metabolic disorder on heifer *p*, within herd-year *i* and in year-month *j*, age at calving *k*, with heterosis effect *m,* recombination effect *n* and inbreeding coefficient *o*;
$Y2_{ijmno}$: Observation for metabolic disorder on young cow cow *p*, within herd-year *i* and in year-month *j*, with heterosis effect *m,* recombination effect *n* and inbreeding coefficient *o*;
$Y3_{ijlmnop}$: Observation for metabolic disorder on older cow cow *p*, within herd-year *i* and in year-month *j*, in parity *l*, with heterosis effect *m,* recombination effect *n* and inbreeding coefficient *o*;

HYi : Herd-year *i*;
YM_j : Year-month *j*;
AGE_C_k : Age at calving for heifers *k*;
PAR_l : Parity for cows *l*;
HET_m : Heterosis class *m*;
REC_n : Recombination class *n*;
INT_o : Inbreeding coefficient *o;*
A_o : Additive genetic effect (or breeding value) of animal *p*;
$PERM_p$: Permanent environment effect *q* on animal *p*;
$Error_{ijkmnop}$: Errorterm of Y1, which is not explained by the model;
$Error_{ijlmnopq}$: Errorterm of Y2, which is not explained by the model.
$Error_{ijlmnopq}$: Errorterm of Y3, which is not explained by the model.

The effects A, PERM and Error are random effects, the remaining effects are fixed effects.

▪ Effects in the model

1. Herd-year of calving;
2. Year-month of calving;
3. Age at calving for heifers;
4. Parity for cows;
5. Heterosis and recombination effect;
6. Inbreeding coefficient;
7. Cow;
8. Permanent environment effect.

Herd-year of calving
The incidence of metabolic disorders varies from one herd to the next. Within a herd, the situation in relation to the traits can also change. The herd effect is therefore estimated for each year. With that, all of the animals that calved in the same herd in the same year end up being compared to one another.

Year-month of calving
With the analysis of metabolic disorders, period of calving, defined as year-month of calving, is taken into account. Period of calving has an effect on the incidence of metabolic disorders.

Age at calving for heifers
With the analysis of metabolic disorders, consideration is given to the age at calving of the heifer. Age namely has an effect on metabolic disorders. For heifers there are 18 different age categories,

with category 1 correcting for age at 20 months or younger. Category 2 through 17 corrects for age at calving from 21 through 37 months. All of the heifers older than 37 months fall into category 18.

Parity for cows
With the analysis of metabolic disorders parity is taken into account. Parity has an effect on the incidence of metabolic disorders. Older cows has more metabolic disorders. All cows with parity 10 or higher fall into the same category.

Heterosis and recombination effect
Heterosis and recombination effects play a role with crossbreeding. They are genetic effects that are not passed on to the offspring. Research showed that corrections need to be made for these effects. The extent of heterosis is defined as the difference in level of the trait in the crossbred with the difference of the parent breeds. Recombination is the loss of the usually positive effect of heterosis and occurs when the earlier obtained crossbred product is crossed back with one of the parent breeds. This is described in E-chapter 7 in more detail.

Inbreeding coefficient
The amount of inbreeding can effect the incidence of metabolic disorders. The higher the inbreeding coefficient the larger the negative effect, this is called inbreeding depression. By including the inbreeding coefficient as an effect in the model, the negative effects of inbreeding on incidence of metabolic disorders are taken into account.

Cow
This is the additive genetic effect of the breeding value, the effect that matters in the end. The variable *animal* contains the (genetic) contribution of an animal to the observation and determines the breeding value of an animal. In addition, when determining the breeding value, all of the information from predecessors and offspring is used as well.

Permanent environment effect
For metabolic disorders, a cow can be scored at various times within a lactation or various times in different lactations (for two or more lactations). The scores within a cow have more in common than just genetics. This extra commonality is called permanent environment effect, an effect of the constant situation in which a cow functions. With the use of a permanent environment effect in the model, various observations on a cow can be used to derive a better estimation of the breeding value.

▪ Parameters

In total, in the breeding value estimation for metabolic disorders, 5 traits are analysed: MFE in parity 2 and 3+ and CKE in parity 1, 2 and 3+. The disorders are analysed as correlated traits. The heritability, repeatability, and genetic standard deviation are shown in Table 1. The heritability is a measure of the fraction explained by genetics. Results are based on univariate analyses for parameter estimation in ASReml. The repeatability is a measure for how much one observation corresponds to a subsequent observation on the same animal. Genetic correlations between metabolic disorders per parity are shown in Table 2, these are based on a bivariate analysis in ASReml.

Table 1. Heritability (h^2), repeatability, and genetic standard deviation for metabolic disorders in parity 1, 2 and 3+

Trait	h^2	repeatability	genetic standard deviation
MFE par 2	0.052		8.41
MFE par 3+	0.035	0.08	7.00
CKE par 1	0.089		7.13
CKE par 2	0.036		6.87
CKE par 3+	0.033	0.05	6.27

Table 2. Genetic correlations (below diagonal) between metabolic disorders

	MFE par 2	MFE par 3+	CKE par 1	CKE par 2	CKE par 3+
MFE par 2					
MFE par 3+	0.81				
CKE par 1	0.40	0.08			
CKE par 2	0.52	0.50	0.54		
CKE par 3+	0.30	0.25	0.26	0.81	

▪ Index – metabolic disorders

The breeding values intended for publication are MFE in parity 3+, and overall breeding value for CKE and an index breeding value for metabolic disorders based on MFE, CKE and subclinical ketosis (SCK). For the breeding value estimation of SCK, see E-chapter 34). The overall breeding value for CKE is calculated from the breeding values for parity 1, parity 2 and parity 3 and higher (3+):

$$BV_i = 0.41 \times BV_{i1} + 0.33 \times BV_{i2} + 0.26 \times BV_{i3+}$$

in which:
BV_i : Overall breeding value for CKE

The derivation of the factors (0.41, 0.33 and 0.26) are described in E-chapter 7. The weighing factors for the first three lactations from the testday model are used.

The heritability for the overall trait for CKE is 0.096. The genetic standard deviation is 6.44.

The average prevalence, relative damage, genetic standard deviation and the relative weight per metabolic disorder is indicated in Table 3. The average costs are based on an estimate of economic values. This is an estimate, because economic costs per metabolic disorders differs a lot in literature. The costs for MFE are about double the costs of CKE. Based on research from Guard(2008), this is $334 and $145 respectively. Based on Yildiz (2018), this is $257 and $109. The costs of subclinical ketosis are about half of the costs of clinical ketosis. Therefore for the index calculation the relative damage is 4:2:1. The relative weight is the proportion of the breeding value that is used in the index. This is based on the relative damage and genetic standard deviation of the trait, as well as correlations between the traits.

Table 3: Average prevalence, relative damage, genetic standard deviation and relative weight per metabolic disorder

Trait	Prevalence	Relative damage	Genetic standard deviation	Relative weight
MFE	18%	4	7.00	0.78
CKE	8%	2	6.44	0.36
SCK	10%	1	3.00	0.08

The index metabolic disorders is derived according to the formula:

$BV_{met.rel} = 100 + 0.78 \times (BV_{mfe} - 100) + 0.36 \times (BV_{cke} - 100) + 0.08 \times (BV_{sck} - 100)$

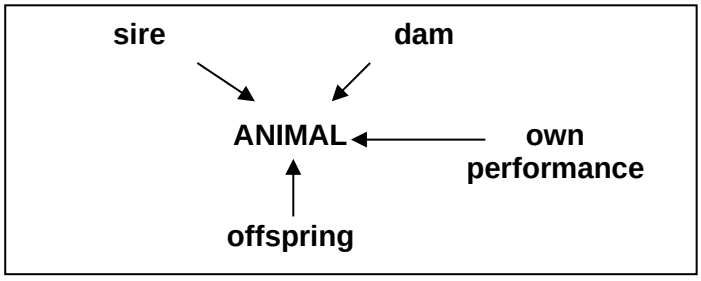
This relative breeding value or index, just like the breeding values for the underlying metabolic disorders, has an average of 100 and a standard deviation of 4.

▪ Reliability

Breeding values are estimations of genetic potential. The word 'estimation' indicates that there is a certain inaccuracy in a breeding value. The reliability of a breeding value indicates the amount of difference that can exist between the estimated breeding value and the true genetic value.

The reliability is dependent on the amount of information available from an animal. There are three information sources:
1. own performance
2. offspring
3. parents

Information about metabolic disorders of (half) sisters, grandparents, etc. is included via the parents; information about granddaughters etc. are included via the offspring.



▪ Base

See chapter 'Bases for breeding values and base differences'.

▪ Publication

Presentation
The breeding values for the metabolic disorders are presented with an average of 100 and a standard deviation of 4. With this it is important to keep in mind that figures above 100 are desirable. An index for metabolic disorders of more than 100 indicates that metabolic disorders will occur *less* frequently in the daughter group.

Publication requirements
See chapter 'Publication rules sires'.

▪ Literature

Guard, C. (2008, October). The costs of common diseases of dairy cattle. In *Proceedings* (pp. 695-700).

Yildiz, A. S. (2018). Effects of some diseases observed at postpartum period of cows in dairy farms: Economic perspective. *Indian Journal of Animal Sciences*, *88*(6), 645-650.