Genetic Evaluation for Ketosis in the Netherlands Based on FTIR Measurements

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Abstract

Ketosis is one of the most common disorders in dairy cows during the early stages of lactation. In the first 60 days after calving, dairy cows are often lacking energy, which can cause metabolic diseases such as ketosis. Since 2012, cows are routinely checked for ketosis in the regular milk recording scheme. The indication for ketosis is based on FTIR measurements of milk acetone and milk beta hydroxybutyric acid (mBHBA). The ketosis indicator also includes fat-protein ratio, lactation number and month of milking. The incidence of ketosis in the Netherlands is 12.2 percent. Using 2.5 million ketosis observations of 1.25 million cows, genetic parameters were estimated with a multi-trait sire model. Heritability for ketosis for lactation 1 was 0.16, for lactation 2 was 0.13, and for lactation 3 was 0.18. Genetic correlation was 0.81 between lactation 1 and 2, 0.58 between lactation 1 and 3, and 0.74 between lactation 2 and 3. In 2014, a routine genetic evaluation was introduced. Breeding values are published as relative breeding value with average of 100 and standard deviation of 4 points, with a higher value resulting in less ketosis. One genetic standard deviation represents 3% ketosis. The genetic trend in the population is slightly positive, resulting in less ketosis. Correlation between ketosis and milk production yield traits are slightly negative, with fertility traits slightly positive (less ketosis results in better fertility results).

Key words: ketosis, dairy cattle, FTIR, genetic evaluation, genetic parameters

Introduction

Ketosis is one of the most common disorders in dairy cows during the early stages of lactation. In the first 60 days after calving, dairy cows are often lacking in energy, which can cause metabolic diseases such as ketosis. The percentage of animals with ketosis per lactation is shown in Table 1. Most ketosis problems occur in higher lactations.

Table 1. Percentage of animals with ketosis per lactation.

Lactation	% animals with ketosis
1	7.49
2	5.24
3+	20.47
Overall	12.20

Ketosis is characterized by an increased level of ketone bodies and health problems like anorexia (Oetzel, 2012). In addition, it has been demonstrated that ketosis negatively affects milk production and reproduction. Ketosis can therefore lead to economic loss due to an increase in the forced culling of animals or higher veterinary costs (Weller, 2013). Milk beta hydroxybutyric acid (mBHBA) and milk acetone, combined with the ratio between milk fat and milk protein, form indicators for establishing ketosis in dairy cows (Van der Drift, 2012 and 2013). Since May 2012, mBHBA and acetone have been routinely measured during regular Milk Production Recording (MPR) in the Netherlands.

In addition to environmental factors (season and management) and animal factors (lactation), genetics also plays a role in the likelihood of developing ketosis. Ketosis has been shown to be a heritable disease, with a heritability of 20%. In addition, there is enough variation in the population to enable selection and therefore to reduce the prevalence of ketosis in the cow population.

The breeding goal is to reduce the incidence of ketosis in the dairy cow population. Less

ketosis brings both improved animal welfare and economic benefits.

Materials and Methods

Data for breeding value estimation

The ketosis indicator is based on FTIR measurements for milk acetone, mBHBA levels, and the milk fat/protein ratio, according to the formula developed by van der Drift (2012, 2013). The ketosis indicator is available in milk recording since May 2012 . For the breeding value estimation only herdbook registered animals with a known sire are used. Only officially approved test days from animals that are 5 to 60 days in milk, are included in the breeding value estimation. The minimum age at calving is 640 days. Fat and protein percentage must be below 10%. Ketosis measurements are log-transformed to correct for the frequency distribution.

In the breeding value estimation of April 2015 there were approximately 4 million observations on 1.56 million animals from 14,000 herds. The total pedigree consists of 3.77 million animals.

Parameters

The parameter estimation was based on 2.5 million observations and 1.25 million animals. Parameters were estimated with a sire model. The genetic variance was estimated as 4 times the sire variance. Permanent environment was corrected for the genetic effect of the cow.

Statistical model

The breeding values for ketosis are estimated with a multiple trait animal model.
The statistical models used, are:

For ketosis lactation 1:

$$Y_{1ijklnopqr} = HY_i + YM_j + DIM_k + L_l + H_n + R_o + A_p + P_q + e_{ijklnopqr}$$

For ketosis lactation 2:

$$Y2_{ijknopqr} = HY_i + YM_j + DIM_k + H_n + R_o + A_p + P_q + e_{ijknopqr}$$

For ketosis lactation 3+:

$$Y3_{ijkmnopqr} = HY_i + YM_j + DIM_k + PAR_m + H_n + R_o + A_p + P_q + e_{ijkmnopqr}$$

where:

Y	Observation for ketosis in heifers, in young cows (lactation 2), and in old cows (lactation 3+).
HY	herd x year of test day;
YM	year x month of test day;
DIM	Days in milk (5 – 60 days) on test day;
L	Age of heifers at calving l (lactation 1);
PAR	Lactation of older cows (lactation 3+);
H	Heterosis effect;
R	Recombination effect;
A	Additive genetic effect ;
P	Permanent environment effect;
e	residual.

The effects A, P and e are random effects, HET and REC are co-variables, and the other effects are fixed effects.

Results and Discussion

Genetic parameters

Table 2 shows the heritabilities, genetic correlations and permanent environmental correlations used in the breeding value estimation for ketosis. Heritabilities are relatively high for a health related trait and range from 0.13 to 0.18. The overall heritability for ketosis is 0.24. Heritabilities are comparable with heritabilities found in literature (Van der Drift *et al.*, 2012).

Table 2. Heritabilities (bold on diagonal), genetic correlations (below diagonal) and permanent environmental correlations (above diagonal) for ketosis.

	Ketosis 1	Ketosis 2	Ketosis 3+
Ketosis 1	**0.16**	0.68	0.61
Ketosis 2	0.81	**0.13**	0.63
Ketosis 3 +	0.58	0.74	**0.18**

The genetic correlations between parities are moderate till high. The genetic correlation between lactation 1 and 2 is with 0.81 the highest correlation. The permanent environmental correlation between lactation 1 and 2 is also highest (0.68).

Effects

In figure 1, 2, and 3 the solutions of the effect of days in milk, season and lactation are shown. Ketosis occurs most in the first three weeks of the lactation, when cows usually have a low negative energy balance (De Vries *et al.*, 2000). The incidence decreases from 19 % at day 10 in milk to 2 % at day 60 (Figure 1). The ketosis incidence in spring and summer is more than doubled compared to autumn and winter (Figure 2). Possibly heat stress plays a role in this. With an increase in lactation number, ketosis incidence increases to a maximum of 25% in lactation 5. The lowest incidence is found in lactation 2 (5%) (Figure 3).

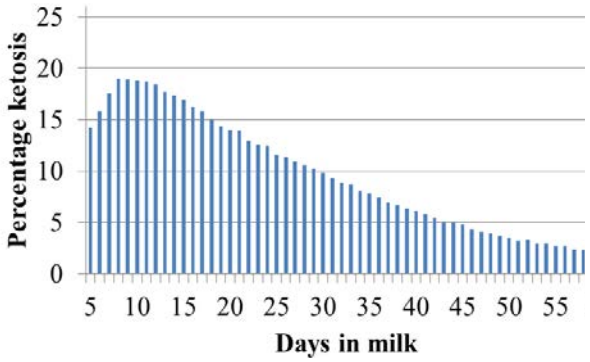

Figure 1. Effect of days in milk on percentage ketosis.

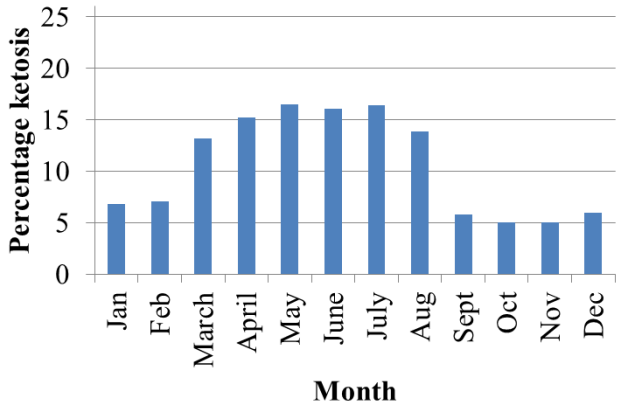

Figure 2. Effect of season (in months) on percentage ketosis.

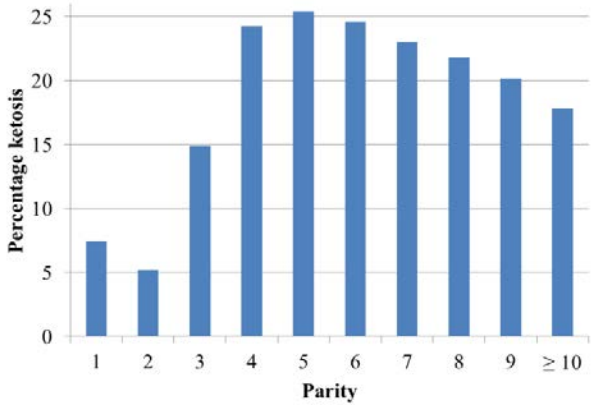

Figure 3. Effect of lactation on percentage ketosis.

Breeding value, genetic trend and reliability

Breeding values are expressed as a relative breeding value, with mean 100 and a standard deviation of 4 points. A breeding value ketosis above 100 indicates that the incidence of ketosis in the daughter group is lower. The effect of a breeding value one standard deviation above average (104) is 3% reduction of overall ketosis. For lactation 1, 2, and 3+ this reduction is 3%, 2% and 5 % respectively.

The distribution of the breeding value ketosis is given in Figure 4. The breeding values follows a normal distribution. The genetic trend and reliability for the breeding value ketosis for Holstein bulls is shown in Figure 5. The trend shows an increase of the breeding value with birth year, implying a decline for the incidence of ketosis. This is mainly due to the positive correlations with udder health and fertility traits; traits on which has been selected for in the last decade. The average reliability of the breeding value is between 45 and 50 % for all Holstein bulls born between 2001 and 2010. When a bull becomes a proven bull (at least 125 daughters), the reliability rapidly increases to 80% or higher.

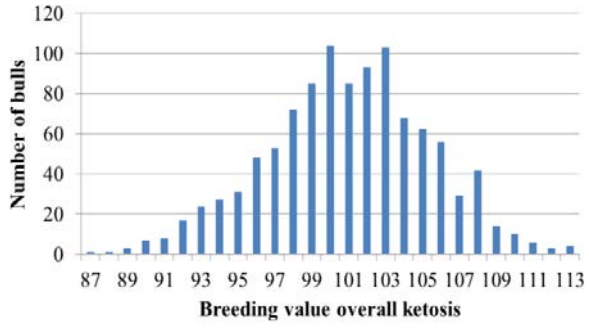

Figure 4. Distribution of the breeding value ketosis.

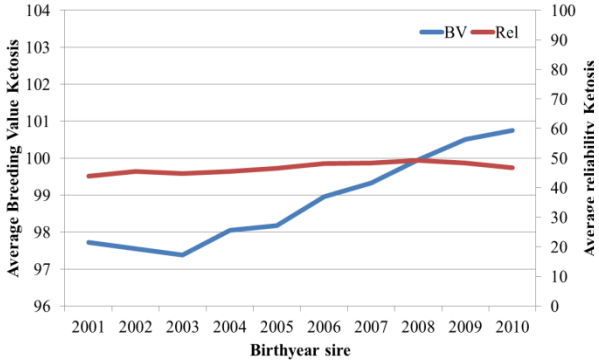

Figure 5. Genetic trend and reliability of the breeding value ketosis, for 87.5% Holstein bulls, included in the April 2015 evaluation.

Table 3. Estimated genetic correlations of the breeding value ketosis with breeding values for production, fertility and udder health traits.

Trait	Correlation with ketosis
Kg milk	-0.28
% fat	0.16
% protein	0.39
Kg fat	-0.15
Kg protein	-0.08
Fertility	0.29
Calving interval	0.33
Intv. Calving – 1st insemination	0.33
Intv. 1st – last insemination	0.26
Udder health index	0.19
Subclinical mastitis	0.21
Clinical mastitis	0.19
Somatic cell score	0.16
Body condition score	0.27
Weight	0.24

Genetic correlations

Estimated genetic correlations of the breeding value for ketosis with breeding values of other traits are shown in Table 3. Bulls that have a high EBV for ketosis also tend to have higher EBV for fertility (correlations between 0.26 – 0.33), and for udder health (correlation 0.19). Regarding the production traits, bulls with a high EBV for ketosis tend to have lower EBV for kg milk (-0.28), but higher EBV for protein percentage (0.39). High producing milking cows want to produce more milk, without enough energy, that causes the negative energy balance, resulting in ketosis. A slightly positive correlation between body condition score and ketosis, and also for weight can be observed. An explanation can be that animals with a higher body condition score and higher weight tend to have more reserves and the energy balance will be less negative, resulting is less ketosis.

Conclusions

The ketosis indicator can be used for a breeding value estimation applying a multi-trait animal model. Data is available through FTIR measurements during regular milk recording. Variation between bulls exists and makes it possible to breed for reduction of ketosis incidence. The heritabilities range from 0.13 to 0.18, with a heritability of 0.24 for the overall trait. Based on estimated genetic correlations, it can be concluded that bulls that score positive for ketosis score also slightly positive for other health traits as fertility and udder health. Bulls that score positive for ketosis score slightly negative for kg milk, but positive for percentage protein.

References

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